Research Article

IoT Board Education Design and Analysis for Elementary School Students

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Abstract.
This study aimed to design and analyse IoT board education for elementary school students as a supporting tool for learning Programming Logic. The Programming Logic Learning curriculum was implemented in elementary schools to develop students' critical thinking. The study used the waterfall method through the following phases: system analysis and requirements, design, development, testing, and implementation. In the performance system test, a trial was done for elementary school students, and a User Acceptance Test (UAT) was done for the Programming Logic subjects. The results of the Black Box Testing showed that all features could run well. Trials of several elementary school students showed that 80% of students were able to use it well and were interested in the IoT board education and UAT testing of The Guardian Teacher, which showed 100% suitability to the needs. In conclusion, the IoT Board Education System can be implemented in Elementary Schools to achieve Programming Logic purposes.

Keywords: IoT, programing logic learning, board education, needs analysis

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1. Introduction

The Internet of Things (IoT) has affected our lives due to its preeminent progression. It may be a rising technology that gives an elite association for making accessible mechanized operations and administrations in different areas. The IoT brings the network to ordinary objects and devices, such as wearables, sensors, and actuators. These IoT devices create a large amount of information that's at that point transmitted to IoT applications, where they are analyzed to make a few yield choices. Researchers, analysts, and businesspeople are inquisitive about the IoT because of its capacity to supply novel administration over a wide range of applications. The IoT depends on information collected by various end devices, and information is collected immediately by physical objects that consolidate sensors and organize the network [1-9]. Many people are learning basic programming logic, but many people do not understand

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basic programming logic. To make it easier to learn basic programming, everyone must understand the principles of programming logic. Because of that, it is easy to order or program an IoT development board technology; the author will build a basic learning logic system to program the IoT Development Board quickly [10].

In this research, they arrange puzzles so that they become one and can later be run on the proposed development board. This software design is used to design software to make it easier to create and write programs that will be implemented. The technique or method used to develop this software uses the Software Development Life Cycle (SDLC) flow method. Software Development Life Cycle is the process of changing and creating systems, models, and methodologies to develop software. This SDLC uses the waterfall method, and it can be concluded that web blocks can be used as a medium for learning basic logic on the IoT Development Board, with the same blocks as the basic logic of programming. This web block is interactive because it requires other blocks to execute the program, so it can attract interest in learning the IoT Development Board and applying Google Blockly as a learning tool for basic programming logic on the IoT Development board. It can be concluded that the web block can be used as a medium for learning basic logic on the IoT Development Board, with the same blocks as the basic logic of programming. This web block is an interactive web because it must require another v block to execute the program so that it can attract interest in learning the IoT Development Board.

This research aims to make an educational IoT board designed for elementary school students that could be used for various purposes, such as introducing students to the Internet of Things (IoT) concept and how connected devices can communicate and interact with each other. Another goal is to teach students basic programming concepts, such as loops and conditional statements, using a visual programming language like Scratch. Another advantage of this developed IoT Board is encouraging creativity and problem-solving skills by challenging students to design and build their own IoT projects. IoT board can provide a hands-on learning experience that helps students understand abstract concepts, such as data collection and analysis, in a concrete and engaging way. Teachers can also enhance classroom instruction by allowing students to collect and analyze data in real time and use it to explore scientific and mathematical concepts, fostering teamwork and collaboration as students work together on projects and share their findings with the class.

2. Research Methods

The waterfall method was applied to build the system through the following phases: system analysis and requirements, design, development, testing, and implementation. The first phase is analysis and requirements. In this phase, researchers analyzed the necessity of building the web. The researcher analyzed the tools needed to build the web and the structure of the IoT Development Board so that a web user can easily drag and drop the IoT component on the IoT Development Board. The second phase is to design the web. The Edu Web IoT was built with a Google Platform based called Blockly. The third phase is the development process. In this phase, the researchers used tools and programming language to develop the web. Testing was done using a user acceptance test. After testing, the final phase was implementation.

2.1. System analysis and requirement

The programming logic for learning IoT that has been designed is called the IoT Development Board. This IoT board is one of the comprehensive solutions for learning logic programming on an IoT basis. The design of the IoT Development Board will be shown in Figure 1 (b). The Board is equipped with a variety of sensors, such as light, temperature, sound, motion, and vibration detectors, to meet the needs of basic-level IoT learning. Sensors and actuators arranged in the Board are shown in Table 1. This Board also features several LEDs, buttons, relays, buzzers, and more. The core of the development board is the utilization of the resources contained in the MCU Node. NodeMCU is an open-source IoT platform. It consists of a wireless device running on the ESP8266 and hardware based on an ESP-12 module. The NodeMCU microcontroller is integrated with Wi-Fi, so there is no need for an additional Wi-Fi chipset. The system design on the chip (SoC) allows communication via GPIO by connecting to the Internet and transmitting data. Based on this, using the MCU Node as the main processor in the IoT Development Board is considered very suitable. Based on the system architecture that has been created, internet access is needed to send messages to the message broker to the device.

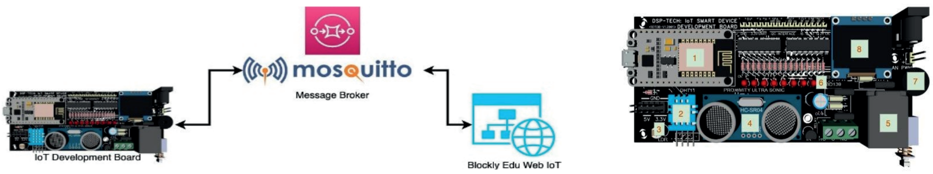
2.2. System architecture design

The system developed has three main aspects: IoT Development Board, Message Broker, and Learning Media. IoT Development Board used sensors DHT11, HC-SR04,

Table 1: IoT development board components.

Component	Function	Component	Function
Node MCU	Micro Controller	Relay	On/off
DHT11	humidity, temperature	LED	The signal on/off
LDR	Light intensity	Buzzer	Sound actuator
HCSR04	distance	LCD	Display information

LDR, FAN, LED, Buzzer, and Relay. The use of these sensors, with the consideration that the essential learning of a microcontroller, requires seven types of sensors. In the system architecture developed, Mosquitto is used as a Message Broker because Mosquitto has MQTT protocol features that are superior in data exchange so that it is easy to apply to various types of IoT devices. The system developed also uses Blockly Edu Web IoT because, in the application, there is a Google Blockly platform where this feature functions as a primary learning medium for Programming Logic utilizing drag-and-drop operations that can attract users' interest.



(a) (b)

Figure 1: (a) architecture system, (b) IoT development board.

2.3. Development

The web was developed with React, a JavaScript library, to build interactive user interfaces. The web also used the Google Blockly library for drag-and-drop operations. The challenge was when Blockly Edu Web IoT connected with IoT Development Board through a message broker and the Internet; the web could control the IoT Development Board as explained in the previous phase.

2.4. Testing

In measuring the level of conformity between user needs, in this case, represented by the Teacher to the system that has been created, it is done using the User Acceptance Test Method [11-19]. Questions on the questionnaire that will be shared with users are questions based on research from Pal et al. [20] as shown in Table 4. Based on the questions in Table 1, an assessment is carried out using a Likert Scale whose rating scale uses five scales, namely: 1. Strongly Disagree, 2. Disagree, 3. Enough, 4. Agree, 5. Strongly Agree. Questionnaires were distributed to teaching teachers. Where there were 30 teachers with an entire gender division of 18 Females and 12 Males, with the average age of the respondents being 34.7 years, each Teacher gets information about how to use it and the features contained in the system. After trying to use the system that has been created, each Teacher will fill out a questionnaire that has been compiled, and Table 5 shows the result of the Teacher's assessment. Based on the table, all the questions asked to get a value above three so that the overall average gets a value of 3.54 which means the system that has been built can be used properly by teachers so that it is expected to improve the quality of learning about programming logic that represents student learning to be logical well.

Table 2: User acceptance test: questionnaire questions.

No	Questionnaire questions
1.	I think that I would like to use this application frequently
2.	I found the application unnecessarily complex
3.	I thought the application was easy to use
4.	I think that I need the support of a technical person to be able to use this application
5.	I found the various functions in the application were well integrated
6.	I thought there was too much inconsistency in this application
7.	I would imagine that most people would learn to use this application very quickly
8.	I found the application very awkward to use
9.	I felt very confident using the application
10.	I needed to learn many things before I could get going with this application

2.5. Implementation

Implementation was done in two steps. First, powered by an IoT Development board, connecting the IoT Development Board to a message broker and Wi-Fi. The second step was connecting the Edu Web IoT to the Wi-Fi so both device and the web could communicate, receive commands and give feedback as a response.

3. Result and Discussion

Table 3: User acceptance test: questionnaire questions.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	3	5	3	2	3	2	3	4	5	3
2	2	4	2	4	2	3	5	5	2	4
3	5	4	3	5	4	3	5	5	3	2
4	3	4	3	5	4	2	2	5	3	4
5	3	3	4	2	4	2	3	3	4	3
6	4	3	5	2	5	2	2	4	3	3
7	4	5	2	4	2	4	5	4	2	2
8	3	4	4	4	2	5	4	2	5	4
9	4	2	4	3	5	4	5	4	3	3
10	2	2	3	2	5	4	3	3	2	3
11	4	4	3	2	3	5	3	5	3	5
12	2	5	5	4	3	4	2	5	4	3
13	4	5	3	4	3	5	4	4	2	5
14	3	5	2	3	5	4	4	2	5	5
15	5	5	4	2	4	4	2	3	4	3
16	5	4	2	2	5	4	3	5	4	3
17	4	2	5	4	2	5	3	4	3	3
18	2	5	5	5	5	5	3	5	4	5
19	2	4	2	2	5	4	4	4	2	4
20	5	5	2	5	3	5	3	4	4	3
21	2	2	2	5	5	3	2	4	3	2
22	2	3	2	4	5	2	3	2	3	4
23	5	2	4	3	5	4	4	2	5	5
24	4	3	5	5	2	3	3	3	3	4
25	5	2	5	4	4	3	2	4	3	3
26	3	5	2	3	5	2	5	4	4	5
27	4	5	2	3	3	2	5	4	3	3
28	4	4	4	3	3	3	3	2	4	5
29	4	3	2	3	4	3	5	3	2	3
30	5	2	2	5	3	4	5	2	4	5

3.1. Functional test

A functional test was performed on the development environment at the laboratory. This test is intended to ensure that each feature or each component of the system is valid. A test case is given to the feature/component to validate whether the actual result is the same as the expected result. Since this functional test is focused on the test case and the result, instead of a detailed process inside, then the Black Box approach is applied. The development of the hardware functional test is shown in Table 1. While Table 1 depicts the result of the available software test.

Table 4: Hardware functional testing.

Component	Test Case	Result	Status
DHT11 (temperature sensor)	Locate the DHT11 or IoT board in a room (lab)	The temperature resulting from DHT11 is similar to other devices	Pass
LDR (light sensor)	Open and close LDR with the hand	Value of LDR changes based on the hand position	Pass
HC-SR04 (ultrasonic sensor)	Move in and move out a hand into/from HC-SR04	Value of HC-SR04 changes based on the hand position	Pass
Relay	Turn on and turn off the relay from the message broker client tool	The relay switched on and off based on the input	Pass
LED	Turn on the LED from the message broker client tool	LED based on the input number	Pass
Buzzer	Turn on and turn off the buzzer from the message broker client tool	Buzzer beep based on the input	Pass
OLED 0.96 inch	Give the treatment to	Displays text of one of the sensor values or actuator conditions	Pass

Table 5: Software functional testing.

Feature	Test Case	Expected Result	Status
Start the workspace	Open the homepage and click the button Start	Workspace opened	Pass
Display blocks in each category (Logic, Math, Custom)	Select a category from Logic, Math, and Custom	Blocks in each category displayed	Pass
Add blocks to the workspace	Click and drag a block into the workspace	The block is added to the workspace	Pass
Run code for LED block	Add a LED block into the workspace and run the code	The LED component turns on	Pass
Run code for relay block	Add a relay block into the workspace and run the code	The relay component turns on	Pass
Run code for buzzer block	Add a buzzer block into the workspace and run code	Buzzer Block was Added to the workspace and ran code	Pass
Run code for fan block	Add a fan block into the workspace and run code	Fan Block added into the workspace and run code	Pass
Run code for temperature block	Add a temperature block into the workspace and run the code	Temperature Block added into the workspace and run code	Pass
Run code for branching/selection logic block	Add an if-else block into the workspace	If-Else Block added to the workspace	Pass

4. Conclusion

The research about the design and analysis of the IoT board has been done and tested. The functional test was performed on the laboratory's development environment. The system can run well according to test scenarios on the software and hardware side, where each design can perform error handling. The user acceptance test is used to confirm whether the system is matched with user analysis. The user Acceptance Test used ten questions asked to the respondents and got a value of 3.54 which means the system can be used properly. From the data above, the researchers conclude that the system is promising to be used in logic programming subjects.

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