Build a Microcontroller Based Interactive Module as A Learning Medium in Vocational Secondary Schools

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Abstract. The purpose of this research is to build an interactive and complete module to be used as a learning medium at the vocational secondary school level. The prototype method is one of the ways that can be used to build microcontroller modules to suit your needs. The prototype methods include communication, planning, modeling, construction, and development. Microcontrollers are one of the learning media that has a high level of difficulty in understanding each device's usage. The trainer module that has been circulating in the market and the students are still not complete and not interactive. During this time, the microcontroller module used focuses on the creation of microcontroller trainer modules using dot matrix, keypad, LCD, digital I/O, and traffic light. In building a complete and interactive microcontroller module, it takes an appropriate method to construct it. Meanwhile, the media needs learning with the development of technology requires a more complete module in addition to the components that are already used in general. In the design of an interactive module, the microcontroller used to have more complete devices including additions to servo motors, potentiometer, temperature sensors, proximity sensors, DC motors, and the addition of WiFi modules as a complete facility of interactive microcontroller modules. The results showed that the features offered had a 50% more complete compared to previous microcontroller modules, and more interactive could use WiFi networks. With the more complete a microcontroller module, it can be easier for students to understand each implementation and can improve the competency of the students in the use of microcontrollers.

1. Introduction
In the educational field, especially the upper secondary education based on vocational is more prioritize practice than with theory. This is because vocational based students are prepared to face the workplace or industry. By implementing learning concepts for the real-world scenario, it can increase the interest and motivation of students to learn [1]. In order to achieve this, it is necessary that education tools can support the purpose. It is because of the need for educational tools development as an additional help system to connect from concept to practical [2].

Current technological developments have been very rapidly, one of them is microcontroller technology. Microcontroller module is one of the learning media that is capable of simulating various programs that can be performed microcontrollers [3]. The use of microcontrollers on training media in schools, in general still felt difficult and not interactive. This makes students aware of the use of microcontrollers [4]. Microcontroller Mastery cannot be separated between theory and practice. Microcontroller exercises can be done using learning media [5]. Meanwhile, to learn better microcontroller materials, the presence of microcontroller training media is required [6]. The training media that has developed nowadays, many microcontroller modules that have been circulating in the market, but among those modules are still separate each function. It poses difficulties to the school parties in preparing each module to study the microcontroller. In addition, learning activities can be
done well if supported by quality and accurate learning medium [7]. Microcontroller modules are now on the market and are used by some schools largely focusing on the manipulation of passive components such as LED lights, stepper motors, DC motors, sensors, and other devices [8]. Whereas, microcontroller needs are now not only limited to the use of passive components only but rather develop with technological developments. In the era of digitizing understanding of microcontrollers and the Internet of Things (IoT) by teachers and students need to be improved both in terms of knowledge, attitude, or skills [9].

Microcontrollers and IoT are vast in all areas of knowledge and technology or engineering. Thus, this research aims to build a complete and interactive microcontroller module based on the use of the Internet of Things to be used as learning media at the vocational secondary school level, so as to improve the competency of the microcontroller understanding.

2. Research Methodology
In this research, several phases are performed in building microcontroller modules. In building our Microcontroller trainer module, we refer to the prototype method stage. The prototype method is used as a stage step in building microcontroller prototypes that will be used as training modules [10]. The stage consists of communication, quick plan, modeling quick design, construction of the prototype, deployment delivery, and feedback, as shown in Figure 1. Stages in the prototype method can be used to build a module microcontroller trainer according to the needs.

![Figure 1. Prototype Method](image)

In Figure 1, there are five stages for the model prototype method, namely:

2.1. Communication
The communication stage is an early stage in the development of a microcontroller trainer module. This stage is done to obtain an overview of problem identification and evaluation of the need for microcontroller kit module development.

2.2. Quick Plan
The quick plan stages are planning by preparing the needs of the support system. Both hardware and software needs for microcontroller kit needs.

2.3. Modeling Quick Design
At this stage, the stage creates an illustration of the system and the device to be used. The need for a software system related to functionalities and hardware is created in model form.

2.4. Construction of Prototype
This step starts the initial construction of the microcontroller module device. Then test each component used [11].
2.5. Deployment Delivery and Feedback
The final step is to send feedback to the system’s tested capabilities. This step is done to repair the system and find every weakness of the system. Therefore, it can fit the initial purpose.

The steps in the prototype method can help build the model trainer kit of microcontrollers needed by students and schools. The prototype method is very well used to solve the problem between users and system needs.

3. Results and Discussion
From the stage of the prototype method, we determine the need for a module to be built that is the need for a microcontroller trainer module with complete and interactive needs. Hence, after fulfilling these needs, we start setting up the Microcontroller module system design as shown in Figure 2.

Figure 2 is a trainer module design built in. In Figure 2 there are several components used are LCD, Keypad, PIR Sensor, LED light, temperature Sensor, ultrasonic Sensor, potentiometer, and trainer module development with IoT-based Wifi communication. Any component located in the Microcontroller module will be tested. Testing includes testing each component through a series of trials.

3.1. Liquid Crystal Display (LCD) test results
On the LCD testing carried out, the data transmission from the microcontroller then displayed on the LCD. The display test on the LCD is by sending the word "Hello, World" and counting the numbers from 0 to 25. Here, the test results on the LCD as shown in Table 1.

| Testing            | Test View             | Result   |
|--------------------|-----------------------|----------|
| Displaying words   | Words “Hello, World”  | Successful |
| Do counter numbers | Counter from 0 to 25  | Successful |

Table 1 shows the results of the LCD test, by displaying the word and counting the numbers with the result successfully done.
3.2. Keypad test results

On the keypad, testing is done by pressing the keypad keys with numbers from the number 1-9 and the asterix character. Here, the test results on the keypad as shown in Table 2.

| Testing            | Test View        | Result     |
|--------------------|------------------|------------|
| Number 1 pressed   | Number 1 is displayed | Successful |
| Number 2 pressed   | Number 2 is displayed | Successful |
| Number 3 pressed   | Number 3 is displayed | Successful |
| Number 4 pressed   | Number 4 is displayed | Successful |
| Number 5 pressed   | Number 5 is displayed | Successful |
| Number 6 pressed   | Number 6 is displayed | Successful |
| Number 7 pressed   | Number 7 is displayed | Successful |
| Number 8 pressed   | Number 8 is displayed | Successful |
| Number 9 pressed   | Number 9 is displayed | Successful |
| Number * pressed   | Number * is displayed | Successful |

Table 2 shows the test result of the keypad, pressing 10 different buttons and successfully completed.

3.3. PIR sensor test results

On the PIR sensor test, the test was performed by performing the movement connected with the lamp. If the sensor detects motion, the light lights up or vice versa. The followings are the test results on the PIR sensor as shown in Table 3.

| Testing            | Output lights | Result     | Description                                           |
|--------------------|---------------|------------|-------------------------------------------------------|
| Make the move      | Lights On     | Successful | Successfully detects movement, and the light is on   |
| Not doing movement | Lights Off    | Successful | Does not detect movement, lights off                   |

Table 3 shows the results of the PIR sensor test, with the movement connected to the lamp. Successfully turn on the light while detecting movement.

3.4. LED light test results

On testing with LED lights, testing using four lamps. Each light will turn on time. The first second, then the lamp will light up is the LED 1. While the second 2 lights are LED lights 2. The third second, the Lit is the 3 LED lights. And the fourth second, the lighted lamp is the 4 LED light. Therefore, the testing is done by turning on the lights alternately based on the number of lamps. The following results of The LED light test as shown in Table 4.
Table 4. LED light test results

| Time (Second) | LED 1 | LED 2 | LED 3 | LED 4 | Description |
|---------------|-------|-------|-------|-------|-------------|
| 1             | On    | Off   | Off   | Off   | Successfully |
| 2             | Off   | On    | Off   | Off   | Successfully |
| 3             | Off   | Off   | On    | Off   | Successfully |
| 4             | Off   | Off   | Off   | On    | Successfully |

Table 4 shows the results of the LED light test, based on the time of each second. The LED light manages to live every second.

3.5. Temperature sensor test results

Tests with a temperature sensor are tested using the LED light indicator as to the temperature marker. The temperature that is tested in the value includes room temperature between 25-40 °C. Temperature testing is divided into four conditions and circumstances. The following are temperature sensor test results against room temperature with LED light conditions (See Table 5).

Table 5. Temperature sensor test results

| Temperature Test (°C) | LED 1 | LED 2 | LED 3 | LED 4 | Description |
|-----------------------|-------|-------|-------|-------|-------------|
| 25 - 27               | On    | Off   | Off   | Off   | Successfully |
| 27 – 29               | On    | On    | Off   | Off   | Successfully |
| 29 – 30               | On    | On    | On    | Off   | Successfully |
| >30                   | On    | On    | On    | On    | Successfully |

Table 5 shows the results of the temperature sensor test, with different temperatures successfully detecting temperature and providing LED light indicators.

3.6. Ultrasonic sensor test results

In testing with ultrasonic sensors, tests were conducted using distance to the LED light. Used four distance conditions against the number of LED lamps. The following condition testing ultrasonic sensors against distances and LED light. The following are the results of ultrasonic sensors (See Table 6).

Table 6. Ultrasonic sensor test results

| Distance Test (cm) | LED 1 | LED 2 | LED 3 | LED 4 | Description |
|--------------------|-------|-------|-------|-------|-------------|
| 25 – 30            | On    | Off   | Off   | Off   | Successfully |
| 30 – 35            | On    | On    | Off   | Off   | Successfully |
| 35 – 40            | On    | On    | On    | Off   | Successfully |
| >40                | On    | On    | On    | On    | Successfully |

Table 6 shows the results of the ultrasonic sensor test, the test results showed that the sensors can detect at various distances.
3.7. Potentiometer test results

On potentiometer testing, tests were conducted by measuring potentiometer voltages and LED indicator lights. Voltage testing is 0-5 Volt voltage. The test is divided into two parts, i.e. testing with a range of 0-2 volts then the LED light indicator turns off. Meanwhile, testing with a range of 3-5 volts then the LED light indicator is on. The following are potentiometer testing results (See Table 7).

| Voltage (Volt) | LED Light | Result  |
|----------------|-----------|---------|
| 0              | Off       | Successfully |
| 1              | Off       | Successfully |
| 2              | Off       | Successfully |
| 3              | On        | Successfully |
| 4              | On        | Successfully |
| 5              | On        | Successfully |

Table 7 shows potentiometer test results, the test results showed that the potentiometer test was successful.

3.8. Wifi communication test results

In wireless testing, testing is done by connecting between applications with the Trainer Kit module through the wireless network. Testing using four pieces of LED light, as well as temperature and humidity sensor communication. Testing is the application to turn on the lights and transmit temperature and humidity sensor data. If in the application of the lamp condition, should the lamp condition in the module trainer Kit should be on living conditions. The followings are test results between the application and the Trainer module through the wireless network (See Table 8).

| Conditions in the application | Conditions in the trainer kit module | Result |
|-------------------------------|------------------------------------|--------|
| LED Light 1 On                | LED Light 1 On                      | Successfully |
| LED Light 1 Off               | LED Light 1 Off                     | Successfully |
| LED Light 2 On                | LED Light 2 On                      | Successfully |
| LED Light 2 Off               | LED Light 2 Off                     | Successfully |
| LED Light 3 On                | LED Light 3 On                      | Successfully |
| LED Light 3 Off               | LED Light 3 Off                     | Successfully |
| LED Light 4 On                | LED Light 4 On                      | Successfully |
| LED Light 4 Off               | LED Light 4 Off                     | Successfully |
| Sending temperature data      | Displaying temperature              | Successfully |
| Sending moisture data         | Displays moisture                   | Successfully |
Table 8 shows the results of the communication test through the wireless network, the test results showed that the interactive modules can be done, between the application and Kit trainer modules can interact through the wireless network.

3.9. Comparison of trainer modules on the market and built

To see the advantages of the modules of microcontroller trainer built, then we perform the process of comparison with the trainer modules that are in the market based on the components and functions provided. The followings are the results (See Table 9).

| Facilities or Component | Market trainer module | Trainer module built |
|-------------------------|-----------------------|----------------------|
| Dot Matrix              | √                     | √                    |
| Keypad                  | √                     | √                    |
| LCD                     | √                     | √                    |
| Motor DC                | √                     | √                    |
| Potentiometer           | -                     | √                    |
| PIR sensor              | -                     | √                    |
| LED Light               | √                     | √                    |
| Temperature sensor      | -                     | √                    |
| Ultrasonic sensor       | -                     | √                    |
| Wifi communication      | -                     | √                    |

Table 9 shows the results of a comparison of the number of modules fittings located on the market with the built. The built-in Trainer Kit module has a more complete benefit of 50% and more interactive. With a series of tests on several components built on the microcontroller module. The development of this module aims to produce a complete microcontroller trainer module, with several combinations of components such as dot matrix, keypad, LCD, DC Motors, potentiometer sensors, PIR sensors, and can communicate over the network Internet. Trainer module If more complete, then facilitate every student who learns to understand each component used. It is because microcontrollers are one of the lessons that have a high level of enthusiasm and help students solve problems structured and systematic [12].

4. Conclusion

Based on the results on the test system module used, the module microcontroller trainer built has the advantage of a more complete component of 50% of the trainer module in the market. Besides, this trainer module has the advantage of being able to communicate interactively between applications and modules using WiFi media.

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