DEVELOPMENT OF A MICROCONTROLLER LABORATORY TRAINER MODULE FOR ENGINEERING STUDENTS

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ABSTRACT

The knowledge of microcontroller to engineering students is essential since it will help them in the development of their prototypes for their design projects. The idea of this study was to develop a laboratory trainer board using arduino microcontroller kit. The developed laboratory trainer module covers sensors, motor, Bluetooth modules, switches, and display. The laboratory module evaluation was assessed through the finished projects using the trainer module. Students were given a survey questionnaire after performing experiments. Based on the results, the microcontroller trainer module was essential in helping students learn hardware programming and microcontroller interfacing.

Keywords —Engineering, Arduino, sensor, Bluetooth, microcontroller, laboratory trainer module, Philippines

INTRODUCTION

A microcontroller is a small computer on a single integrated circuit, which contains a processor core, memory, and programmable input/output peripherals (Bannatyne & Viot, 1997). A microcontroller is widely used nowadays in almost every application such as printers, remote control, and modern automobile. Because of its usefulness, engineering students find it essential in building design prototypes for their thesis related projects. Microprocessor and Design Projects are important subjects required to complete their course (Hamad, Kassem, Jabr, Bechara, & Khattar, 2006). In these subjects, students are required to learn the concepts of Microprocessor system and its purpose. However, the previous researches use the older version of Programmable Interface Controller (PIC) microcontroller for their laboratory experiments (Hamad et al., 2006), where they need external clock and other components for it to function properly. Hence, previous designs were prone to complications.

In Cor Jesu College, the courses Microprocessor Systems (ECE/CpE 423) and Design Projects (ECE 511/CpE 510) are two of the important subjects required for engineering students to complete their course. In these subjects, students are required to learn and understand the concepts of a microcontroller and their purpose. These students conduct laboratory activity by taking the electronic components,

module, and other devices piece by piece during lab activity. These components are prone to damage or loss, disorganization, and non-systematic laboratory activity. With this scenario, the components and microcontroller modules are easily damaged due to electrostatic discharge brought by humans to the components. For this reason, the proponents decided to develop a trainer module that integrates and organizes various microcontrollers, electronic module, and other devices to limit electrostatic discharge. It allows students to earn self-pace the concepts of hardware programming (Hamad et al., 2006).

The main goal of this study was to assist students in prototyping their future projects; enhance user's programming skills in hardware applications, and help the students in understanding the concept presented in the laboratory experiments.

MATERIALS AND METHOD

The design integrated microcontroller and other electronic components in one development trainer module to have an organized laboratory activity not prone to damages of the electronic components and modules.

Arduino development board was chosen by the proponents as the microcontroller to be used in the design because of its flexibility with interactive objects or environments (Wang, Lim, Wang, Leach, & Man, 2014). Arduino Integrated Developments Environment is an open-source (Wang et al., 2014) and is available to many Operating Systems like Windows, Linux, and Mac OS. It can be programmed in C programming language and the Integrated Developments Environment has loads of examples, which can be easily understood, as a start.

1. Hardware Design

The hardware design, as shown in figure 1, illustrates the process and connection of components of the trainer board. The power supply is the device that produces electric power to the trainer board. The microcontroller is a small computer in a single integrated circuit (Bannatyne & Viot, 1997). It is where the program is to be loaded for laboratory exercises. The servo motor and display are components that generate visual or moving output. The tact switch and keypad are components where data can be entered as input to be processed by the microcontroller. The Bluetooth module is a wireless communication (Asadullah & Ullah, 2017) device that enables electronics to connect with arduino microcontroller via Bluetooth connection via Android Phone (Chen, Zhang, & Wang, 2018). The Global System for Mobile communication (GSM) is a module that enables the electronic component to receive/send text messages (Madhura, Poojalakshmi, & Pravin, 2017) or call via Telecommunication Network. GSM module can control different electrical appliances (Teymourzadeh, Ahmed, Chan, & Hoong, 2013) via text messaging.

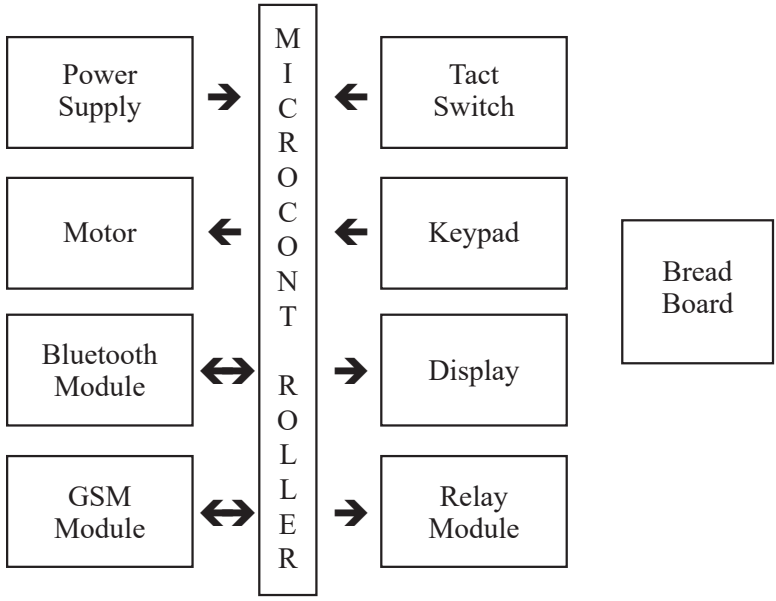

Figure 1. Block Diagram of the Hardware Components

2. System Flowchart

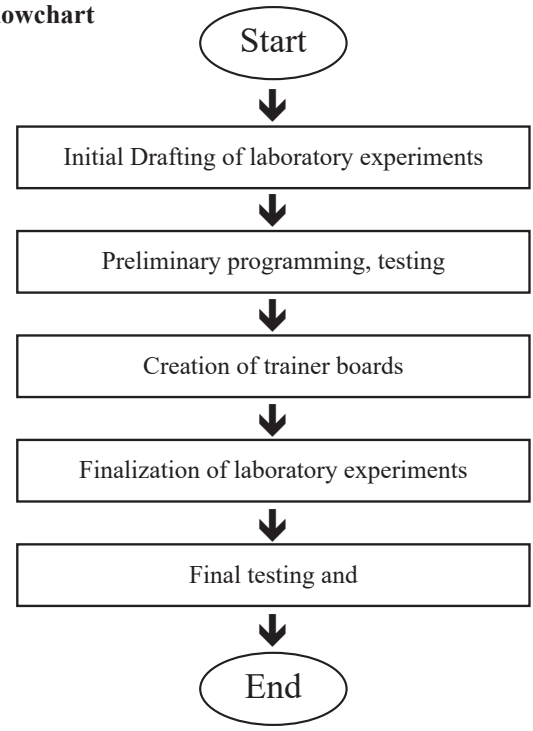

Figure 2: System flowchart of the Design

Figure 2 shows the design and step-by-step process in developing the trainer module. It started with the initial drafting of the laboratory experiments. Objectives were formulated, and exercises were created for each experiment. Initial circuit schematic diagrams to be used were also designed. The next step was the preliminary programming, testing, and debugging. The Arduino program source codes for the exercises in each experiment were created. These exercises were performed and tested by downloading the source code to Arduino and build the corresponding circuit diagram to be used on a breadboard. Necessary adjustments to the program source codes and circuit schematic diagrams were also performed.

The creation of a laboratory trainer module was done. The circuit schematic diagrams for each experiment were designed and tested successfully. The circuit designs were transferred into printed circuit boards. Creating PCB layouts, etching, drilling, soldering, and debugging PCB connectivity were performed in this step. Finally, testing and debugging were performed. All the laboratory experiments were conducted following the laboratory manual draft that was created earlier as a reference. The trainer boards were tested and debugged for problems until all were successfully working. With all those processes, the finalization of the laboratory experiments was done. The initial draft for the laboratory experiments was finalized as a laboratory manual following the format below for each laboratory experiment, like Experiment number and experiment title; Objectives; Equipment and Materials; Discussion; Trainer Board Reference Schematic Diagram; Procedures; and Activities. The final prototype is shown in figure 3.

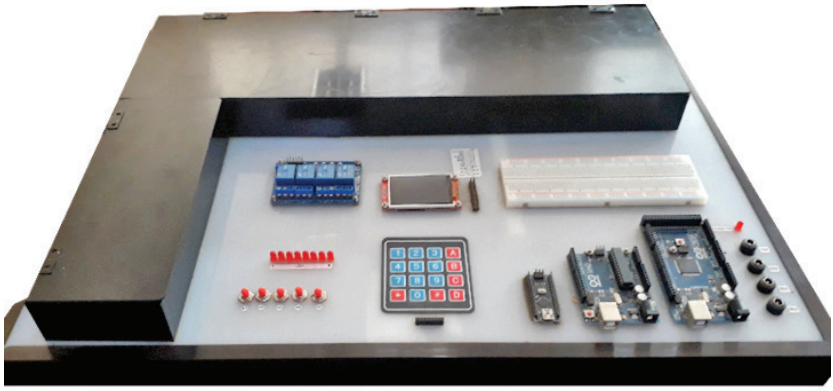

Figure 3. Final Prototype

RESULTS AND DISCUSSION

The finalized laboratory trainer module helps the students in completing the student's final requirement in their major subjects. Figure 4-a shows the finished line follower robot; figure 4-b shows the completed Biometric Attendance System. Figure 4-c shows some of the wireless-controlled designs. All finished projects underwent programming, testing, and debugging using the newly developed microcontroller laboratory trainer board.

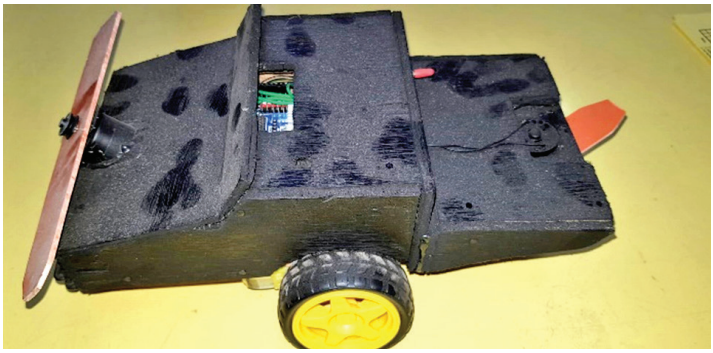

Figure 4-a: Line Follower Robot

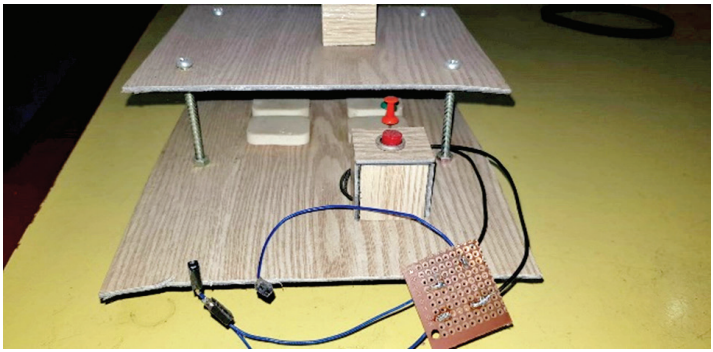

Figure 4-b: Biometrics Attendance System

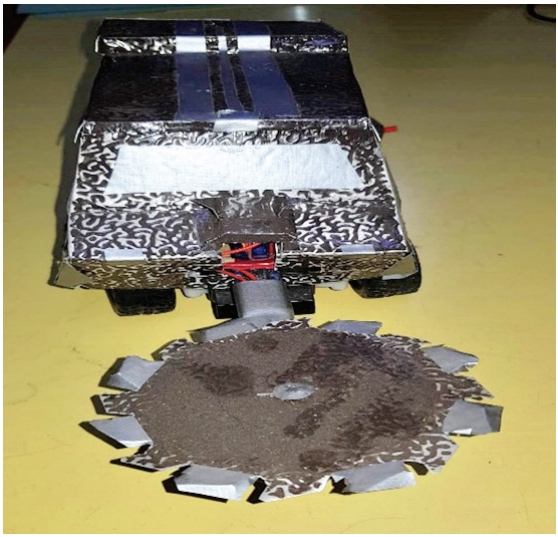

Figure 4-c: Bluetooth-controlled Robot

Finally, the survey questionnaire was distributed to eight pairs of students who have the background on electronics, Circuits, and C++ programming but have little or no background on programming microcontrollers.

Every time a pair finished an experiment, they were required to answer a laboratory assessment form to evaluate their experience in the performed experiment.

The data gathered from the answered laboratory assessment forms were separated into three sections: laboratory experiment section, trainer board section, and the self-assessment section.

Table 1
Laboratory experiment evaluation summary table

Statements	Overall Weighted Mean	Interpretation
1. The discussion is clear in introducing the basic concepts necessary to perform the experiment.	4.9	Very High
2. The schematic diagram is readable and understandable.	4.85	Very High
3. The procedures are clear and easy to follow.	4.95	Very High
4. The activities are easy to perform.	4.85	Very High
5. The objectives of the experiment have been met.	5	Very High

Table 2
Trainer Board evaluation summary table

Statements	Overall Weighted Mean	Interpretation
1. The trainer board is suited to the experiment to be performed.	4.8	Very High
2. The trainer board is helpful in understanding and performing the experiment.	4.85	Very High

Table 3
Self-assessment evaluation summary table

Statements	Overall Weighted Mean	Interpretation
1. I am confident that I could apply the concepts I learned in the experiment using an Arduino board	4.95	Very High
2. I am confident that the knowledge I obtained will be helpful in learning and using other kinds of microcontroller	4.9	Very High

Table 1 shows the evaluation of the laboratory experiment section. The respondents rated very high that the discussion in the experiment was clear, the schematic diagram was readable, the procedures were easy to follow, the activities were easy to perform, and the process of the performed experiment had been met. Table 2 shows the evaluation of the trainer board evaluation section. The two statements both received a very high rating. It means that the respondents agreed that the trainer board was suited to the experiment to be performed and is helpful in understanding and performing the experiment. For the self-evaluation section, as shown in Table 3, the respondents also rated very high. It means that they are confident that they could apply the concepts they learned in the experiment using Arduino board, and the knowledge they obtained is very helpful in learning and using different kinds of a microcontroller.

CONCLUSION AND RECOMMENDATION

The evaluation of the respondents showed that the created laboratory trainer module helped the students in interfacing microcontroller and improved their hardware programming skills. Line follower robots, running message board, and other wireless-controlled design projects were successfully done. Also, based on the results gathered from the survey questionnaire, the interpretation of the results shows that the developed trainer module helped the students in understanding the concepts presented in the laboratory experiments. Similarly, it enhanced their confidence in creating future design projects. Finally, the researchers concluded that the developed microcontroller trainer module is an essential aid in learning the concepts of microcontrollers.

Despite the success of the development of the microcontroller trainer board, it is still considered as a continuing projecy. Thus, some points are considered for future enhancement. Improved components or modules and better design can be applied to make the design best suitable that can be implemented for other applications. For larger applications that need multiple tasking of outputs or design projects that requires larger memory and database, it is highly recommended to include a Raspberry Pi in the laboratory module. It is also recommended to include Pi Camera Module and LCD Monitor for future designs that need digital image processing.

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