Evaluation of Embedded System Component Utilized in
Delivery Integrated Design Project Course

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Abstract. This paper reports the evaluation of the embedded system component utilized in delivering the integrated electronic engineering design project course. The evaluation is conducted based on the report project submitted as to fulfil the assessment criteria for the integrated electronic engineering design project course named; engineering system design. Six projects were assessed in this evaluation. The evaluation covers the type of controller, programming language and the number of embedded component utilization as well. From the evaluation, the C-programming based language is the best solution preferred by the students which provide them flexibility in the programming. Moreover, the Analog to Digital converter is intensively used in the projects which include sensors in their proposed design. As a conclusion, in delivering the integrated design project course, the knowledge over the embedded system solution is very important since the high density of the knowledge acquired in accomplishing the project assigned.

1. Introduction

Nowadays, the revolution of technology is moving towards the Industrial Revolution (IR) 4.0 which includes the cyber-physical systems, the Internet of things, cloud computing and cognitive computing as reported in [1-2]. Undoubtedly, all the area listed in the IR 4.0 required the integration of the embedded system in solving the problem towards creating the new solution. In more specific, the integration of the system required expert to detail out the requirement and analysis over the subsystem integration of embedded system before the deployment taking part especially for the embedded system controller.

On the other hand, in embedded system technology, there are enormous numbers of embedded solution available on the shelf which allowed the system integrator and designer to choose the best as to accomplish their idea on the solution development according to their project and design constraints [3]. The selection can be in the form of lower end of the embedded solution up to the high-end without neglect that the cost and level of complexity of the solution are the others influencing factors as well to be considered.
Despite from the demand in the industry, the electronic engineering based degree program will be exposed to the embedded system course as to prepare the students with the current technology used in the industry. Although the implementation of the course is differing from one university to the others, the important fundamental element to expose the student with the embedded system controller is the main idea of the course implementation. This includes the basic knowledge of the embedded system exposure and the utilization of the embedded system towards completion of the specific engineering problem given.

In Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam Selangor, Malaysia, the fundamental of embedded system is teach in semester 6 under the Embedded System Design and Interfacing course. As to apply the knowledge acquired, an Engineering System Design was introduced at semester 8 which required the student to use the fundamental knowledge acquired from the subject to solve the engineering problem and come out with a complete prototype of the project. As to evaluate the density of knowledge used in the project, this paper will assess the component of embedded system utilized in the project based on the main important components taught at the embedded system course.

2. Methodology of Evaluation
The evaluation was conducted at Faculty of Electrical Engineering Universiti Teknologi MARA Shah Alam, Selangor, Malaysia. A group of Bachelor of Electronics Engineering degree program student taking Engineering System Design course from March 2017 to July 2017 session were assessed in this studies. There are six projects submitted by the student with the main theme to design new equipment and tools for material and devices fabrication process laboratory. The evaluation is conducted by assessing the component of embedded system used in the project from the final report and prototype submitted by the student at the end of the semester.

3. Result and Discussion
There are six completed projects have been assessed in this embedded system component assessment including the Low Cost Spin Coater Machine as shown in Figure 1.

As depicted in the Figure 1, the Low Cost Spin Coater Machine is using ATmega2560 development board as main controller, keypad to control the speed level and timing for coating, motor as a spinner, vacuum pump to hold the slide and LCD as display and indicator. Moreover, the detail projects submitted and assessed in this embedded system component assessment are listed in Table 1.
Table 1. List of the project submitted for Engineering System Design course

| No | Project Title                  | Description of Project                                                                 |
|----|--------------------------------|----------------------------------------------------------------------------------------|
| 1  | Hot Plate Stirrer Machine      | The project is to design and develop a complete hot plate stirrer at low cost which function to heat and stir the sample at the same time. |
| 2  | Low Cost Spin Coater Machine   | The project is to design and develop a reliable and low cost spin coating machine which function to deposit uniformly thin film to the substrate. |
| 3  | Low Cost Dry Cabinet           | The project is to design and develop a low cost dry cabinet which function to provide a dry and low level of humidity container. |
| 4  | Dip Coating Machine           | The project is to design and develop a low cost dip coating machine which function to dip and formation of thin film. |
| 5  | Ultrasonic Cleaner            | The project is to design and develop ultrasonic cleaner which function is to remove the contamination from the object with high frequency of sound waves. |
| 6  | Glove Box                      | The project is to design and develop glove box which function is to provide the sealed container for allow one to manipulate objects. |

As recorded in Table 1, the main objective of the project is to design and develop a new solution for the material and fabrication research laboratory with 66.7% focusing on producing low cost solution as their main focus or element in their design. In addition, the type of controller is one of the main influencing factors for the cost of the project. Therefore, the type of microcontroller and its main board type were assessed in this evaluation and the result is summarized in Table 2.

Table 2. List of the controller type and main board used in the project

| No | Project Title                  | Type of Microcontroller | Main Board   |
|----|--------------------------------|-------------------------|--------------|
| 1  | Hot Plate Stirrer Machine      | ATmega 2560             | Development board |
| 2  | Low Cost Spin Coater Machine   | ATmega 2560             | Development board |
| 3  | Low Cost Dry Cabinet           | ATmega 2560             | Development board |
| 4  | Dip Coating Machine           | ATmega 2560             | Development board |
| 5  | Ultrasonic Cleaner            | ATmega 2560             | Development board |
| 6  | Glove Box                      | ATmega 2560             | Development board |

As summarized in Table 2, all of the projects are using Arduino platform which one of the famous cost effective open-source electronic prototyping platform been used before in many of the prototyping...
As recorded in Table 3, all of the projects are using more than 16 inputs and outputs to support the sensor and others components connected to the microcontroller. Therefore, the ATmega2560 are been selected to support the inputs and outputs requirement. On the other hand, the mix of mounting type of technology are recorded in the projects; SMT and through hole. All of the projects are developing their own PCB as their application board to be connected to the ATmega2560 prototyping board. From the
list of components used in the project, all of the projects are using LCD to display the status, setting and configuration of their project.

**Table 4. Embedded system software based component assessment**

| No | Software assessment | components | List of Project |
|----|---------------------|------------|-----------------|
|    |                     |            | 1   | 2   | 3   | 4   | 5   | 6   |
| 1.1 | Liquid crystal display |            | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 1.2 | Secure Digital (SD) memory function |            |     |     |     |     |     |     |
| 1.3 | Serial Peripheral Interface (SPI) |            | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 1.4 | Basic digital input/output function |            | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 1.5 | Analogue to digital converter (ADC) |            | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 1.6 | Keypad function |            | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 1.7 | Interrupt function |            | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |

| Type of programming language for microcontroller |
|--------------------------------------------------|
| 2.1 Assembly language | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 2.2 C/C++ programming language | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |
| 2.3 Mix of both | ✓   | ✓   | ✓   | ✓   | ✓   | ✓   |

As recorded in Table 4, all of the projects are using C/C++ programming as their programming language for the project. Moreover, In Serial Programming (ISP) method was used to program the microcontroller for all of the projects. All of the projects are using basic digital input/output function in their project as to control the switches, LED and buzzer. Although the ADC function is significantly related to the interfacing of the analogue sensor, three projects are using this ADC function to read their sensors value to the microcontroller. The interrupt function has been used by (1), (2) and (4) as to control the operation of the machine.

4. Conclusion
Evidently, the embedded system components are intensively utilised in delivery the engineering system design project proposed. These assessments clearly show that adoption of the embedded system components is very high in delivery and successful implementing the engineering system design project with almost all of the components learn are covered in completion of the project. Finally, this is shows that, the implementation of integrated design project is the best platform for students to apply their embedded system knowledge intensively.

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