A Capstone project entitled

To develop a simple intrusion detection system (burglar alarm) using Arduino - A set of teaching materials (12 chapters)

Submitted by

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Declaration

I, *Yeung Kin Wui Anthony* , declare that this capstone project report represents my own work under the supervision of *Mr. Chui Hin Leung, Mike*, and that it has not been submitted previously for examination to any tertiary institution.

Signed _____

Yeung Kin Wui Anthony

10 April, 2019

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1. Introduction

When it comes to the teaching materials for Arduino, there are a variety of free resources available on the internet, including those from the official Arduino website, or those from open-source sharing platform such as GitHub and Reddit. That makes me think of an issue: How about if teachers directly utilizing those materials to teach secondary school students? However, some of those materials can be demanding, which fails to cater the learning needs of students. Moreover, for those teaching materials, some chapters can be discrete without using real-life examples for explanation. In view of this, I have developed a set of interconnected teaching materials, with the use of real-life examples (the burglar alarm), to systematically nurture students' STEM capabilities.

2. Description of the problems (Needs analysis)

Prior to the development of the teaching materials, it is vital to think of the reasons of developing a new set of teaching materials. In simple words, it means "*why developing a new set of teaching materials, instead of using the available ones on the internet?*"

2.1 Coherence between teaching chapters

As mentioned, we can discover free resources for Arduino on the internet. However, some of the chapters can be discrete for students to learn. For example, PIR sensors are taught in chapter 1, and ultrasonic sensors are taught in chapter 2. Although students may grasp the basic ideas of both individually, how about the relationships and differences between them? For example, the pros & cons of utilizing PIR sensors and ultrasonic sensors for motion detection. In view of this, in my new set of teaching materials, the relationships between different kind of sensors will be introduced to students, as well as different integrations of sensors into a burglar alarm system.

2.2 Catering for students' diverse learning needs

In this project, my target users will be Form 3 students, but when having looked at some Arduino resources online, I discovered they may not suit the learning needs of Form 3 students. For instance, some online tutorials are delivered in a text and coding-based approach (*see pic. 1*), and some are designed for learners with certain experiences on Arduino so that no lead-in activities (*see pic.1 & 2*) are provided for beginners.

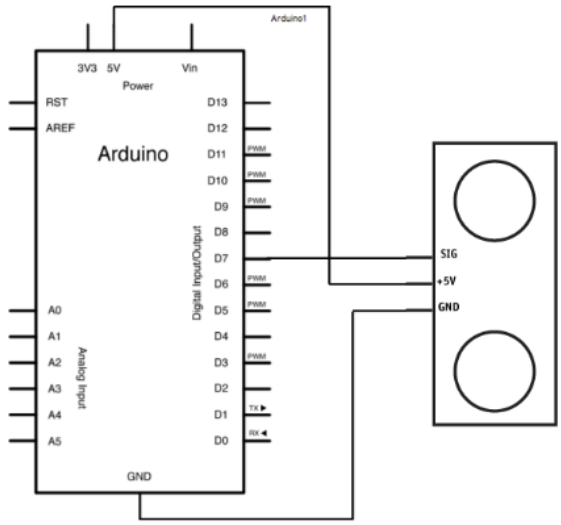
Ping Ultrasonic Range Finder

The SEN136B5B is an ultrasonic range finder from Seeedstudio. It detects the distance of the closest object in front of the sensor (from 3 cm up to 400 cm). It works by sending out a burst of ultrasound and listening for the echo when it bounces off of an object. It *pings* the obstacles with ultrasound. The Arduino or Genuino board sends a short pulse to trigger the detection, then listens for a pulse on the same pin using the pulseIn() function. The duration of this second pulse is equal to the time taken by the ultrasound to travel to the object and back to the sensor. Using the speed of sound, this time can be converted to distance.

Pic. 1. Online tutorials of ultrasonic sensors from official Arduino website

Schematic

click the image to enlarge



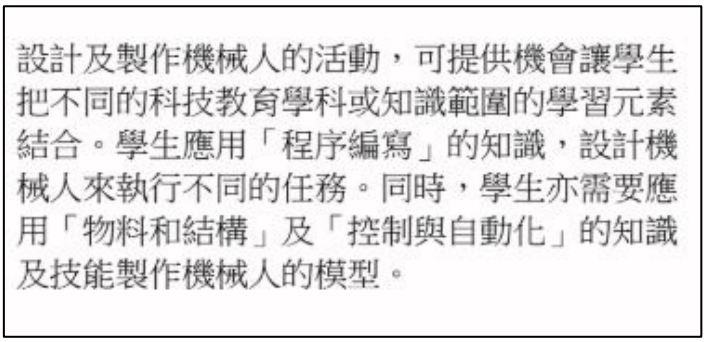
Pic. 2. Online tutorials of ultrasonic sensors from official Arduino website

In this sense, my new set of teaching materials are designed based on the ability of Form 3 students, with a range of lead-in activities & hands-on practices at different difficulty levels, to cater the diverse learning needs of Form 3 students.

3. Literature review

3.1 Target level of students

With reference to the curriculum document by the Education Bureau (2017), "*coding*" is one of the major teaching areas of Form 3 Computer Literacy. The document also stated not less than 30% of lesson time should be allocated to teach coding, which implies the importance of coding education at junior secondary level. Moreover, the curriculum document also provided an example of implementation of Form 3 STEM (*see pic. 2*):


設計及製作機械人的活動，可提供機會讓學生把不同的科技教育學科或知識範圍的學習元素結合。學生應用「程序編寫」的知識，設計機械人來執行不同的任務。同時，學生亦需要應用「物料和結構」及「控制與自動化」的知識及技能製作機械人的模型。

Pic.3. an example of F.3 STEM stated in EDB's curriculum document

All in all, by considering the capabilities of Form 3 students, as well as the learning targets of them in IT area as stated in the EDB's curriculum document, F.3 students are chosen as the target of the new set of teaching materials.

3.2 Sensors selection

To ensure the practicability of the example (*intrusion detection/burglar alarm*) used in the teaching materials, understanding the functions that a modern burglar alarm will offer is vital. With reference to Marked (2013), one of the major purposes of burglar alarms is to identify intrusions, and deliver alerts whenever intrusions are detected. Moreover, Budijono, Andrianto, & Noor (2014) stated that, the detection of motions is the major mission of a burglar alarm, and it can be done using different kinds of sensors, such as PIR sensors, ultrasonic sensors, piezo (vibration) sensors and so on. They also added that, a burglar alarm should be able to generate alerts upon any detection of suspicious motions, and it can be done via different means, such as generating sirens, making lights to blinks, sending SMS notifications to security guards.

Based on the literature review, and the consideration of the capabilities of F.3 students, the sensors that will be introduced & taught (*burglar alarms as a real-life example*) in the set of teaching materials are as follows:

- *PIR sensor*
- *LED units*
- *Ultrasonic sensor*
- *Active buzzer*
- *Passive buzzer*
- *SW420 vibration sensor*
- *I2C 1602a LCD*
- *RC522 RFID module*

4. Description of the project (project design)

In the appendix, there is a Gantt chart showing the general development stages of the teaching materials starting from sketch to completion:

4.1 Learning objectives

Below is the list of chapters in the set of teaching materials:

- *Chapter 1 – PIR sensor*
- *Chapter 2 – LED units*
- *Chapter 3 – Ultrasonic sensor*
- *Chapter 4 – Active buzzer*
- *Chapter 5 – Passive buzzer*
- *Chapter 6 – SW420 vibration sensor*
- *Chapter 7 – I2C 1602a LCD (I)*
- *Chapter 8 – I2C 1602a LCD (II)*
- *Chapter 9 – RC522 RFID module (I)*
- *Chapter 10 – RC522 RFID module (II)*
- *Chapter 11 – RC522 RFID module (III)*
- *Chapter 12 – Consolidation*

All chapters, except chapter 12, are provided with a worksheet

In general, the learning objectives of these chapters are divided into three domains, namely *cognitive domain*, *affective domain* and *skill domain*, and they are listed below:

Cognitive domain: *To equip students with basic programming techniques (e.g. if-then-else clause) through the Arduino project*

Affective domain: *To nurture students' computational thinking capability through the development process*

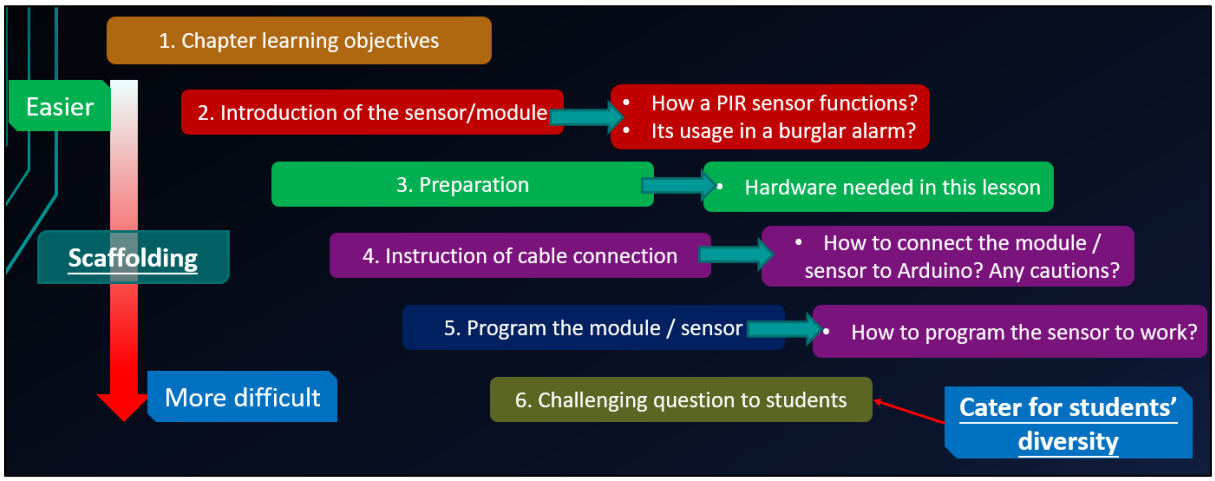
Skill domain: *To enable students with skills to assemble different kind of sensor into a functioning system (burglar alarm)*

As for the lesson objectives of each chapter, please refer to the teaching slides.

4.2 Instructional design

4.2.1 Scaffolding

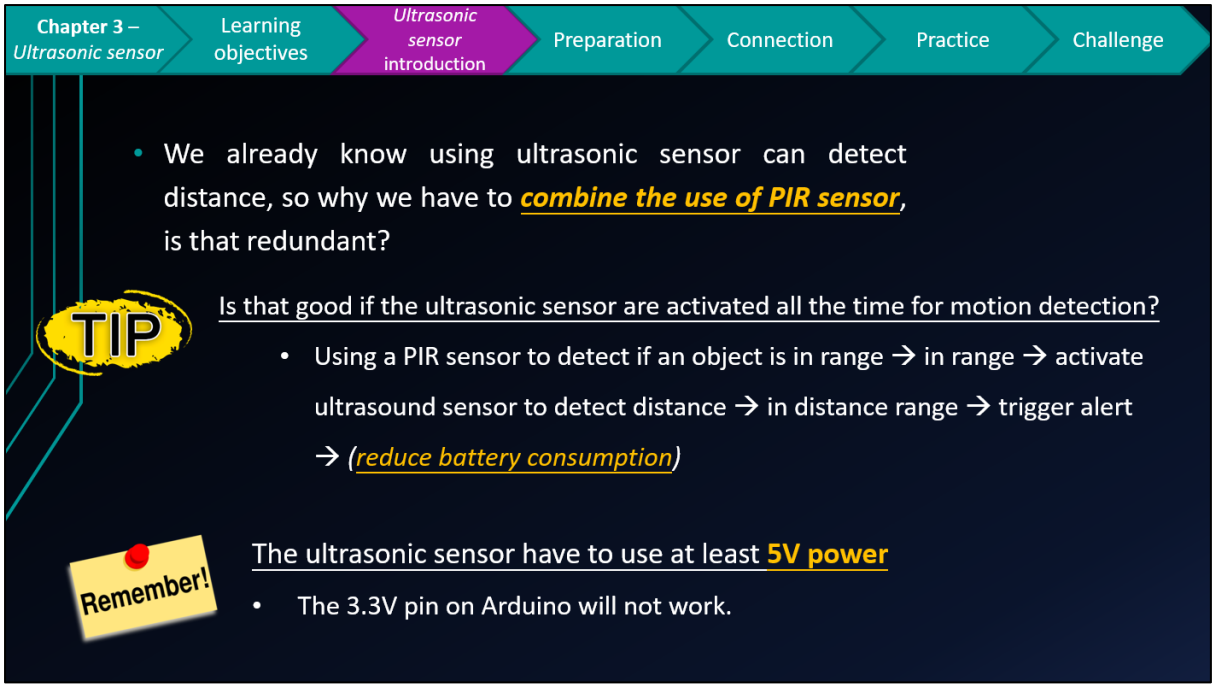
In order to equip students with the ability to develop a burglar alarm independently according to different requirements, scaffolding design is used in the teaching materials. For example, in each of the chapters, students will first start with some easier tasks such as understanding the how a sensor work, then moving to more difficult tasks such as the hands-on practice of connecting a sensor to Arduino and program the sensor to work.



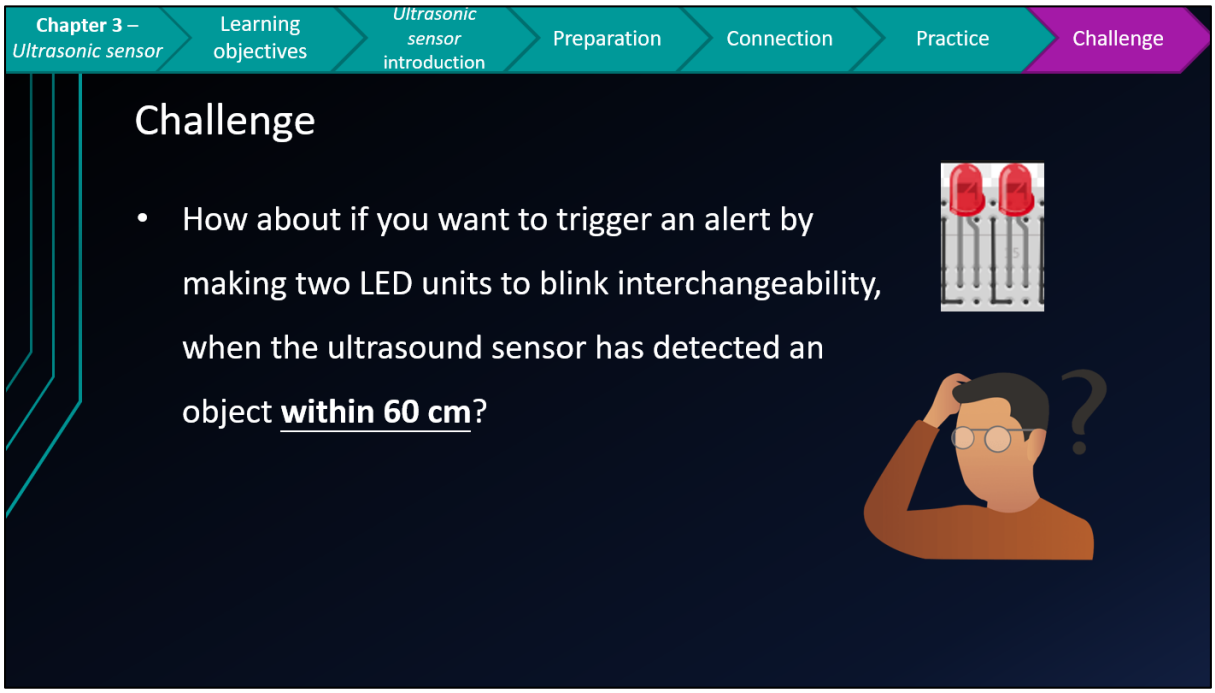
A graphical representation of the scaffolding approach used

4.2.2 Cater for learners' diversity

In order to cater for the learning needs of students at different level, for the teaching materials in each chapter, tips and reminder will be included to help the less-able students to follow the contents being taught easier. For the more-able students, it is possible that the can finish the lesson tasks quickly. To ensure their interest to the lesson content, challenging task will also be also be included as an enrichment at higher level for the competent students. In fact, the challenging task is not just serving the purpose of keeping students' interest, but it also foreshadows the teaching contents of next chapter.



Tips and reminder for less-able students



Challenging tasks for more-able students

4.3 Chosen platform

In the set of teaching materials, the **Arduino Mega 2560** and the **official Arduino IDE** are selected for the development of the burglar alarm system. The justifications of the decision are that the Arduino Mega 2560 provides more digital pins for sensors and modules than Arduino UNO. Moreover, the total current allowed on Arduino Mega 2560 is higher than Arduino UNO, which may ensure the stability of the system when there are a lot of components connected to the mainboard.

4.4 Difficulties encountered & solutions

At the very beginning, Arduino UNO was chosen instead of Arduino Mega 2560. However, during the testing phase, I discovered some readings from sensors are abnormal (*e.g. -1000 from shock sensor*), but when connecting only the affected sensor to UNO, there was no problem with the readings. Having read the specification sheet of Arduino carefully, I discover the culprit may be the overcurrent issue, which means the connect sensors may have exceed the maximum allowed current of Arduino UNO. Later, I changed the mainboard to Arduino Mega 2560 and it solved the problem.

5. Evaluation and future improvement

For the teaching materials, the target students can gain more experiences on some essential techniques on integrating different kind of modules into a functioning system by having hands-on practices on developing a burglar alarm on Arduino platform. Having said that, the type of sensors covered in the teaching materials cannot reflect the full functionality of a burglar alarm system in real-world. For instance, the example of the burglar alarm in the teaching materials could be more comprehensive if few chapters are added to teach students on how to utilize a GSM module to send notification(alert) SMS upon detections of intrusions. Still, the capabilities of the target students have to be considered before making such adjustments.

6. References / Bibliography

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