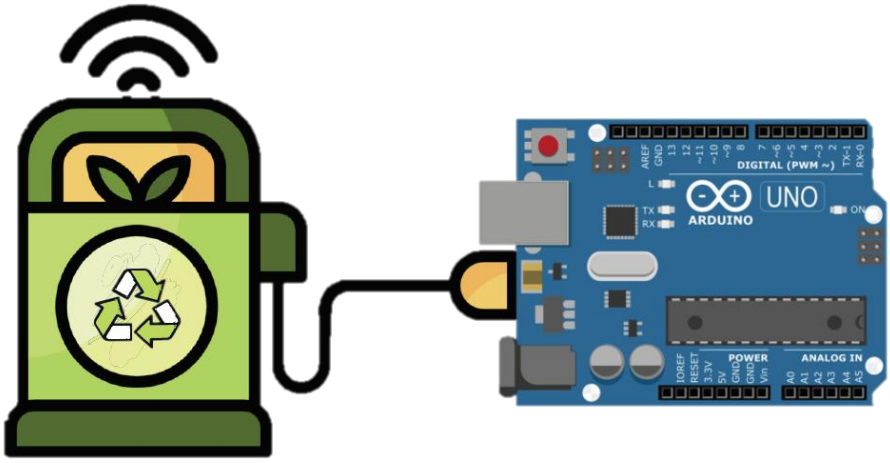
INT 4901 HONOURS PROJECT II

Capstone Project Final Report



To develop a smart recycling bin by using Arduino (10 sets of teaching materials)

Name: Chau Cheuk Lam Esti

Supervisor: Mr. Chui Hin Leung, Mike

submitted to The Education University of Hong Kong

for the degree of Bachelor of Education (Honours)(Secondary) - Information and Communication Technology

THE EDUCATION UNIVERSITY OF HONG KONG
BACHELOR OF EDUCATION (HONOURS) PROGRAMMES
(5-YEAR FULL-TIME) OFFERED BY
THE DEPARTMENT OF MATHEMATICS AND INFORMATION TECHNOLOGY

Declaration Form

I hereby declare that this work has not been submitted previously for examination to any tertiary institution.

CHAU CHEUK LAM ESTI	
Name in BLOCK LETTERS	Student No.
	Mr. Chui Hin Leung, Mike
EDUHK Email	Supervisor Name
	08/04/2021
Signature	Date

Content

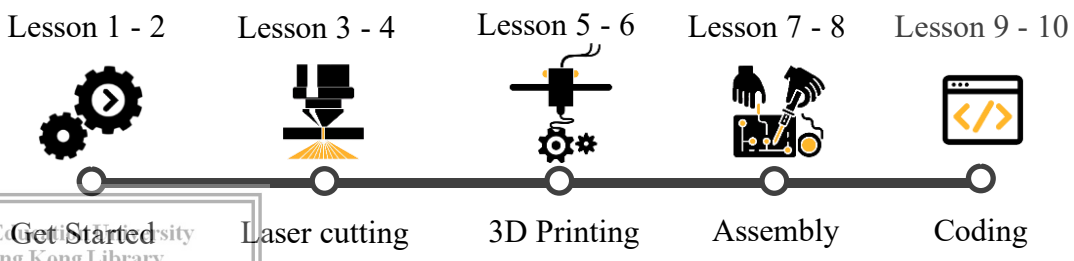
1. Introduction

In Hong Kong, STEM is always considered as a hot teaching topic. Most of the teaching materials focus on one specific area: teaching micro:bit, Arduino, or laser cutting separately. It is hard for students to integrate the knowledge together by themselves. Someone may think of some open resources, like YouTube, to help them utilize their skills. However, fractured teaching content can hardly cater to different learning needs. Sometimes, those projects are irrelevant to daily life experiences. In light of this, I dedicated to creating a set of well-organized teaching materials, cultivating students' integrated skills towards laser cutting, 3D printing, and Arduino through a real-life example (Smart recycling bin).

2. Significance of the study (Needs analysis)

2.1 The linkage in between the whole project

Lesson planning is essential to assist teachers in ensuring that the daily practices and activities can produce long-term progress toward the learning outcomes (Allyn & Bacon, 2008). Many open-source teaching materials teach students to make a product under a particular topic, such as making a box using laser cutting or creating a name badge using 3D printing. Although students understand the basic concepts of the topics, they cannot make the product on top of existing materials. The new teaching package introduced tailor-made 3D printing and laser cutting parts based on the current situation by taking this reason into account. It connected all the components into the smart recycling bin. (See the development timeline below)



2.2 In response to the change of teaching format

Because of the pandemic, information and communication technology (ICT) have been widely used in education. Online teaching and learning have been appreciated and accepted by schools and students. Given this, I created an online learning platform, including hands-on activities, teaching videos, and worksheets, for the package, which is a controllable environment, learning flexibility, and ease of use. In the long run, this set of lessons is not limited to personal use but share with other teachers or students for self-learning. The learning platform also facilitates sustainability such as the continuous development with the updates of new content. Please visit the site (See figure 1): https://sites.google.com/s.eduhk.hk/esti-cp/introduction

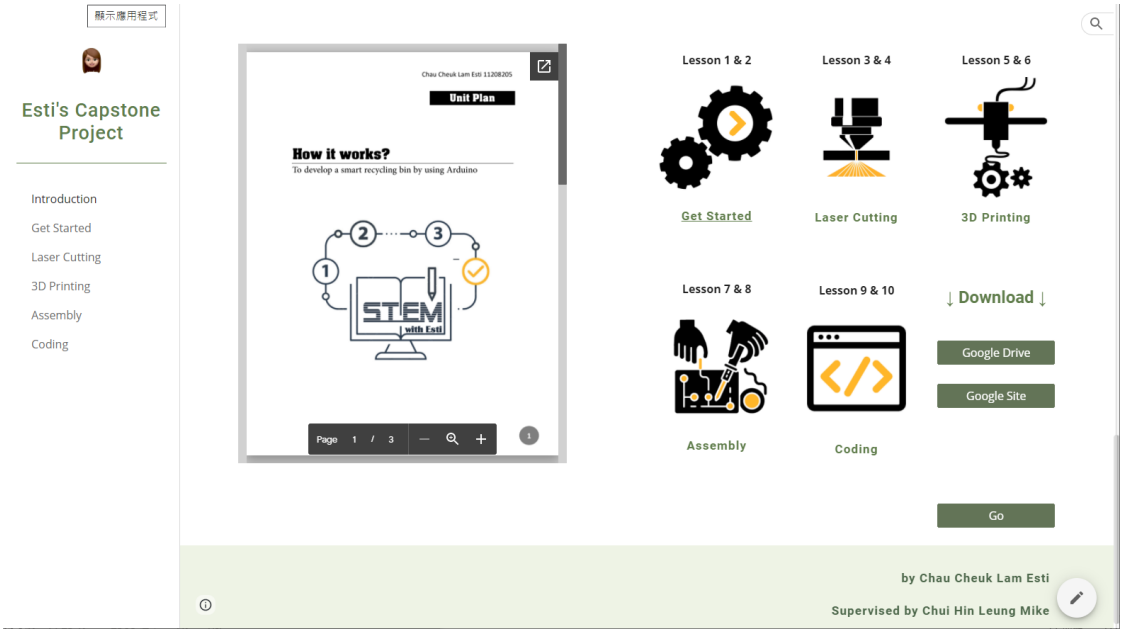


Figure 1: Esti's Capstone Project Website

3. Literature review

3.1 Target students

This learning targets Form 3 students. Students use programming concepts to control sensors and motors throughout the learning process, raise their awareness of the importance of recycling, the integrative use of 3D printer and laser cutter, and create a 2D graphics and 3D computer aided design (CAD) to express the ideas. EDB (2017) promoted a set of key learning areas which stated that Form 3 students should enquire Programming Concepts (K2), Materials and Resources (K3), Tools and Equipment (K5), and Production Process (K6). (See Table 2)

Learning element	Content
(K2) Programming Concepts	Data manipulation • Relational operators (>, >=, <, <=, = and <>) and logical operators (AND, OR and NOT) • Daily life examples of the use of looping
(K3) Materials and Resources	Reuse and recycle of resources • Awareness of the use and disposal of materials may affect the natural environment • Understanding of the importance of reusing and recycling resources for the sustainable development of our society
(K5) Tools and Equipment	Appropriate choice and use of tools, equipment and machines for realisation of design solution • Application of a range of machines to realize solutions to design problems - Lathe - Vacuum former - Laser cutter - 3D printer
(K6) Production Process	Basic elements of design • Basic concepts of CAD and 3D modeling • Application of IT tools such as CAD software to present design ideas

(Table 2. Key learning area extracted from EDB, 2017)

By considering Form 3 students' learning targets and their capabilities, S3 students have become that targeted students.

3.2 Selection of teaching content

In the curriculum context of Hong Kong, STEM education is promoted through Science, Technology, and Mathematics Education. (EDB, 2016) Although EDB suggests that STEM courses should cover all four areas, a majority of them only cover two or three areas. That is why the package covers all four areas (See Table 3).

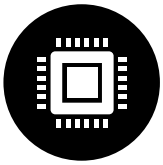
 Science	Distinguish the difference between the materials – aluminum, plastic, paper-based on their properties
 Technology	Draw 2D graphics and 3D models by using Fusion 360 and CorelDRAW and use coding to control sensors and motors.
 Engineering	Assembly the electronic circuit and connect sensors and motors to the laser cutting parts.
 Mathematics	Measure the actual size of the things with tools, like calipers and protractor, and compare the collected data from sensors

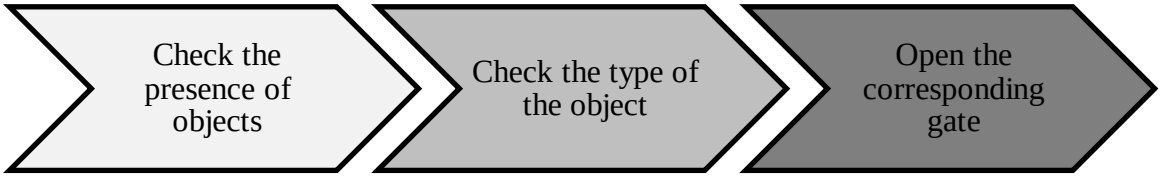
Table 3. Content of the package

Furner & Kumar (2007) suggest an integrated curriculum offers comparatively perfect, more stimulating, more relevant experiences for learners. Therefore, the course involved all elements in STEM. Moore et al. (2014) also agreed that a successful STEM class is based on the connections between real-world problems and the subjects. So, the project aims to tackle one of the environmental problems - recycling.

3.3 Sensors and motors control

The intelligent recycling bin is used to distinguish the source of domestic waste – metal, paper, and plastic. (Environmental Protection Department, 2019) As no particular sensors to figure out the type of objects, the system test the characteristics of the objects, for instance, conductivity and density.

The system can be divided into three parts:



3.3.1 Check the presence of objects

Evans, Noble, and Hochenbaum (2013) stated that ultrasonic sensors emit sonic waves to discover an object's presence. The ultrasonic sensor then turns on the receiving mode and waits for responses after emitting waves. (Figure 2) So, the system uses an ultrasonic sensor to detect waste in the first place.

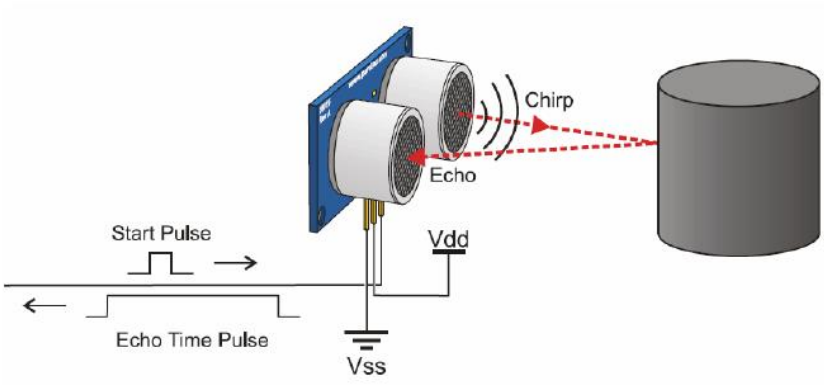


Figure 4: Working principle of Ultrasonic sensor (Source: Engiz and Bashiz, 2019)

3.3.2 Check Object Types

After that, the smart rubbish bin requires distinguishing metal, plastic, and paper. For metal, the system used a non-contact metal detector. Inductive proximity sensors can detect the existence of metal without direct contact to the sensor. By using this sensor, intelligent recycling can dig out metal from paper and plastic.

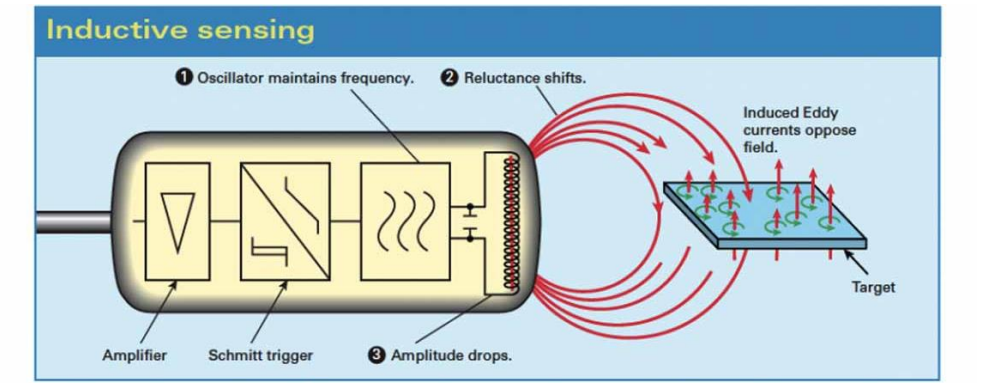


Figure 5: Working principle of metal detector

(Source: Innovation discoveries, 2020)

The system used a light sensor to figure out plastics and papers from three kinds of materials. Light dependent resistors (LDR) sensors can distinguish between papers and plastics reference to the level of light intensity, which the detection range of plastic and paper are above 500lx and below 500lx, respectively (Hassan, Saad, & Raklan, 2018).

3.3.3 Recycling bin rotation

For opening the gate and rotating the motor arm, the system used 25kg servo motor, thicker and more rigid. (Adiningsih, Fitriadi, & Ramdhani, 2018)

Figure 6: 25kg Servo Motor

4 Project design

4.1 Learning objectives

The teaching timeline is shown below (Complete project development timeline, please see Appendix):

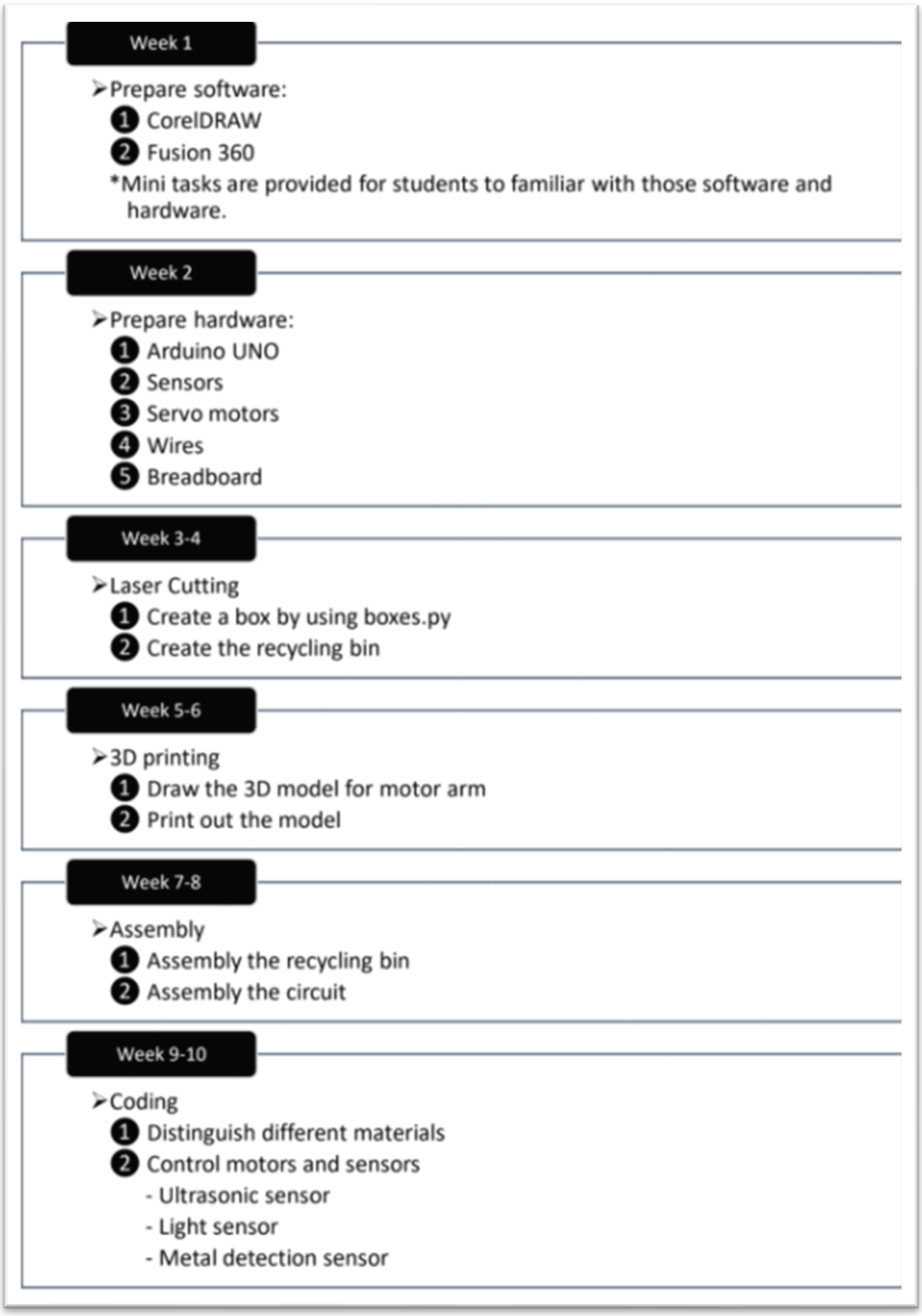


Figure 7. Extracted from the course package – unit plan

In short, the overall learning objectives can be divided into three domains (See below):

Domain	Intended Learning Outcome
Cognitive Domain	Control the Arduino components by coding.
Affective Domain	Cultivate students' problem-solving skills and computational thinking ability. Raise their awareness of the environmental issues.
Skill Domain	Use 2D and 3D CAD to express their ideas. Assembly the circuit with sensors, motors, 3D printing parts and laser cutting parts.

4.2 Scaffolding

Making sure all the learners and teachers can fully understand the course content, the teaching materials are scaffolding. In the beginning, there are two lessons to help them to be familiar with the use of CorelDRAW and recognize the usage of Arduino components. After that, they can move on to more complicated tasks, for example, create a tailor-made 2D graphic with software and laser cutter.

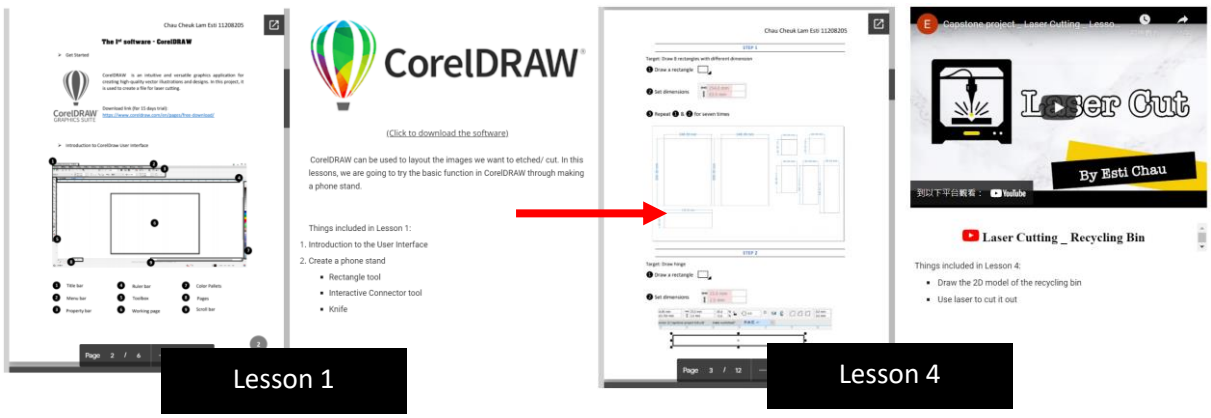


Figure 8. The relationship between lesson 1 and lesson 4

All the step-by-step worksheets provide complete descriptions and well-illustrated. (See figure. 9)

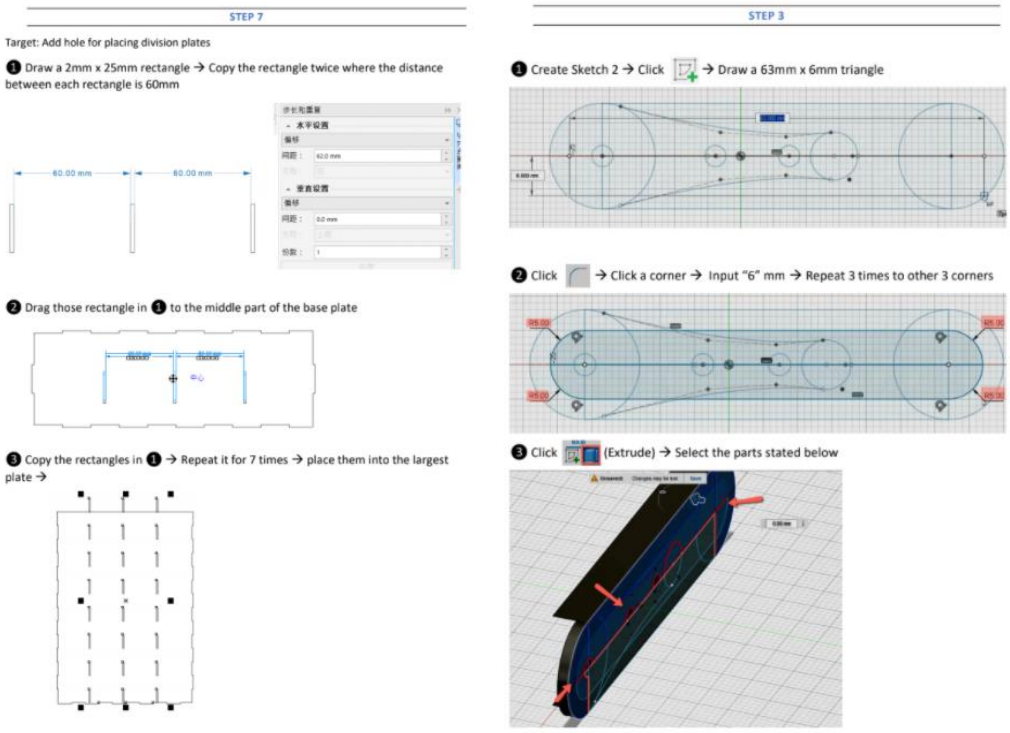


Figure 9. Sample worksheets

4.3 Promote integrated skills

Usually, problems cannot be solved by a single technique but combine with different skills. For example, the smart recycling bin comprises electronic circuits, 3D printing parts, laser cutting parts, and Arduino sensors. The concepts involved are complex, including Science – distinguish the characteristics of the materials, Technology – draw 2D graphs and 3D models with software, Engineering – weld the circuit, and Mathematics – measure the size and compare data. This approach can help students to equip the ability to use acquired knowledge fully.

4.4 Course platform with teaching materials

All the course materials and guidelines were placed on the learning platform created by the Google Sites. Videos, hands-on activities, and worksheets have been embedded on the site. Because of this reason, teachers and students can access the course content easily.

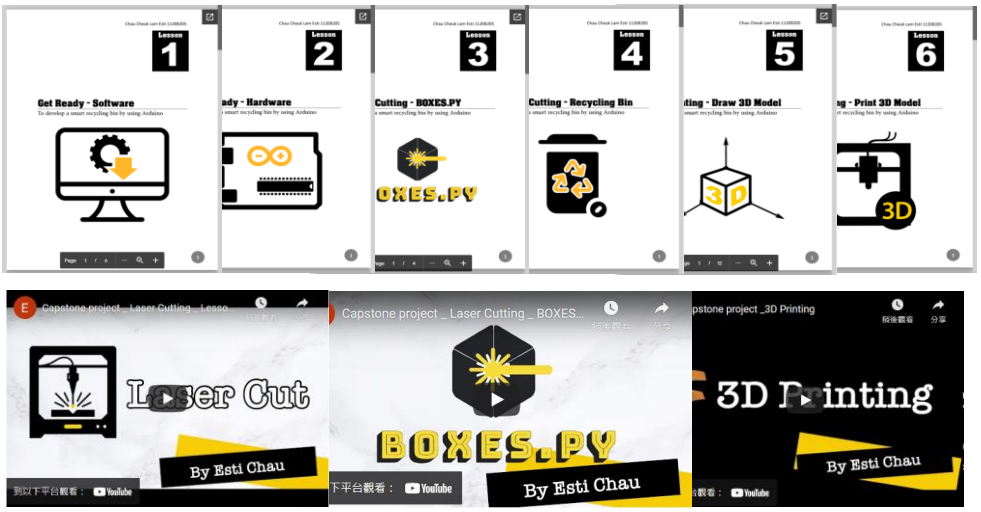


Figure 10. sample worksheets and videos

4.5 Problems encountered and solutions

The original design of the recycling bin container was failed. The design changed from a rounded shape to a rectangular shape by reference to the coin counting machine's design. (Figure 11) Luckily, my supervisor and I came to an agreement that adopts the latest version. As a prototype is editable, easier for stimulating and testing, we can modify it effectively. That is why prototyping is important, before building an actual model.

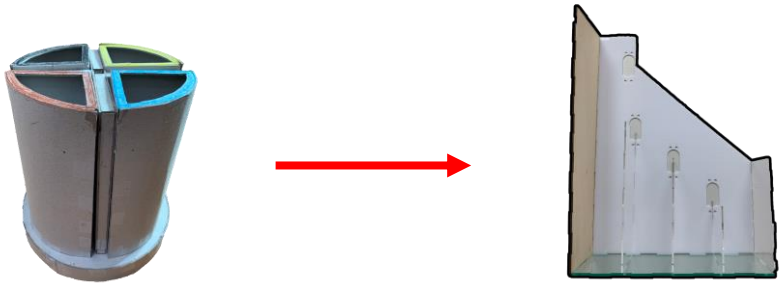


Figure 11. Final design of the smart rubbish bin

5 Evaluation and future improvement

Two ICT students were invited to fill in the peer evaluation form (See Appendix B) to ensure the teaching materials' efficiency. Their responses are positive. Moreover, they both agreed that the package could help cultivate students toward understanding the topics. Cross topics learning sharpen their integrated skills and put their knowledge in solving real-world problems. The current model is only a prototype. It would be great to see this model in a real industry.

6 Reference

[1] Engiz, B. K., & Bashir, R. (2019). *Implementation of a Speed Control System Using Arduino.* 2019 6th International Conference on Electrical and Electronics Engineering (ICEEE). doi:10.1109/iceee2019.2019.00063

[2] Environmental Protection Department (2019). *Programme on Source Separation of Domestic Waste.* Retrieved from https://www.wastereduction.gov.hk/sites/default/files/CHI04_2.pdf.

[3] Evans, M., Noble, J. J., & Hochenbaum, J. (2013). *Arduino in action.* Shelter Island: Manning.

[4] Furner, J. M., & Kumar, D. D. (2007). The mathematics and SCIENCE Integration argument: A stand for teacher education. EURASIA Journal of Mathematics, Science and Technology Education, 3(3). doi:10.12973/ejmste/75397

[5] Hassan, H., Saad, F., & Raklan, M. S. (2018). *A Low-Cost Automated Sorting Recycle Bin powered by Arduino Microcontroller.* 2018 IEEE Conference on Systems, Process and Control (ICSPC). doi:10.1109/spc.2018.8704146

[6] Innovation discoveries. (2020). *What is proximity sensor, its types and working.* Retrieved from http://innovationdiscoveries.space/what-is-proximity-sensor-its-types-and-working/

[7] The Curriculum Development Council (2017). *Technology Education Key Learning Area Curriculum Guide (Primary 1 – Secondary 6).*

7 Appendix

A. Project schedule

TASK	ASSIGNED TO		START	END
Phase 1	Project Conception and Initiation			
Task 1	Discuss the project topic with supervisor	100%	2020-08-03	2020-08-31
Task 2	Submit project proposal	100%	2020-09-01	2020-09-05
Task 3	Modify the project scale	100%	2020-11-20	2020-11-30
Task 4	Finalize CP proposal	100%	2020-12-11	2020-12-11
Phase 2	Project Definition and Planning			
Task 1	Consult about the component list & budget	100%	2020-10-20	2020-10-30
Task 2	Purchase required components	100%	2020-11-01	2020-11-30
Task 3	Design the project and package outline with ILOs	100%	2021-12-01	2021-01-31
Task 4	Video making for all the tutorial lessons	100%	2021-12-01	2021-01-31
Phase 3	System improvement			
Task 1	Test for each function	100%	2021-02-01	2021-02-20
Task 2	1st improvement: Debugging and modify the teaching package	100%	2021-02-01	2021-02-20
Task 3	2nd improvement: Modifying the design based on supervisor's suggestion	100%	2021-02-20	2021-02-25
Task 4	3rd improvement: Increasing the readability of all the materials	100%	2021-02-26	2021-02-28
Task 5	Finalize the whole project	100%	2021-03-05	2021-03-10
Phase 4	Final Project Report			
Task 1	Prepare pictures and content flow for the final project report	100%	2021-03-11	2021-03-15
Task 2	Draft the final project report	100%	2021-03-15	2021-03-30
Task 3	Finalize the final project after consulting with the supervisor	100%	2021-04-01	2021-04-05
Task 4	Submit final project	100%	2021-04-08	2021-04-08