SUSTAINABLE SYSTEM

PROCEEDINGS OF ELECTRICAL ENGINEERING CAPSTONE SHOWCASE (EECS 2020)

COMMUNICATION ENGINEERING DIVISION
SCHOOL OF ELECTRICAL ENGINEERING
FACULTY OF ENGINEERING
UNIVERSITI TEKNOLOGI MALAYSIA

SESSION 2020/2021
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PROCEEDINGS OF
ELECTRICAL ENGINEERING CAPSTONE SHOWCASE

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PREFACE

The publication consists of all the work presented during Electrical Engineering Capstone Showcase (EECS 2020), which was held on 25th January 2021. The EECS 2020 was hosted virtually by the School of Electrical Engineering, Universiti Teknologi Malaysia. The meeting gathers students to share and exhibit their ideas and projects, with academicians and industrial representatives to provide valuable feedback for improvements.

In essence, the Capstone Project provides students with the opportunity to integrate technical knowledge and generic skills attained in their early years. A group of students, an academic supervisor and with optional of industry partner as the advisor, share their experiences in a collaborative project. These experiences comprise objectives, benefits, challenges and lessons learned both from an educational and research viewpoint (i.e., students, supervisors) and the industry and community viewpoint (customer).

The projects reported in the Proceedings of Electrical Engineering Showcase 2021: Sustainable System could serve as motivation and valuable information for future collaborative projects and for the betterment of the society.

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IoT Based Smart Monitoring Food Wastes Composter

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Abstract: The current food waste management is cantered at UTM Dusun thus not all food waste can be processed by UTM Dusun due to the huge amount of food waste produced by each cafeterias every day. This report proposed about a capstone project which is an IoT-based Smart Monitoring Composter. The food Composting Bin is integrated with IoT and microcontroller for smart monitoring and notification alert systems. The bin used Blynk mobile application to monitor and control all the activities via WIFI connection from NodeMCU WIFI module.

Keywords: capstone; food waste; IoT-based Smart Monitoring Composter

1 Introduction

Food waste problems have become a major issue in SKE faculty since past years. UTM Dusun already develops a food waste management centre but due to the huge amount of food waste produced, they cannot process all food waste altogether. Based on the surveys done among the SKE affiliates, most of them find that food waste management in faculty needs to be improved. Moreover, many of them don't know how to compost food waste since there is no exposure and awareness campaign regarding this problem.

From the survey data, our group decided to develop an IoT-based smart monitoring composter bin based on the Bokashi composting method. As mentioned from (Colleen Vanderlinden,2019), Bokashi is one of the solutions used to compost food waste easily by using fermented compose technique which is faster compared to natural food compose. The other reason to choose the Bokashi composting technique is because it produces minimal odour since the process takes place in an air sealed Bokashi bin which is an anaerobic process that is free from oxygen (Planet Natural,2020). The effective microorganism inside the Bokashi powder is a living culture that lives by eating the food waste and turning them into fermented compost in two weeks before the compost is ready to use.

This product also highlights the Internet of Things (IoT) as the main features, so as mentioned by (Jen Clark, 2016), it uses the internet as a connection between two devices to integrate data from Blynk to the Arduino devices at Bokashi bin. For the software parts, it consists of Arduino programming and Blynk mobile application features for monitoring and controlling purposes. This product will then use ESP8226 NodeMCU as a WIFI module for internet connection source. The implementation of IoT technology will help improve the product effectiveness with less effort used in the composting process which can help people to start compost food waste with effective methods.

1.1 Project Objectives

1. To design a smart compressor system and smart monitoring system.
2. To implement the WIFI controlled system using ESP8266 NodeMCU and Blynk.
3. To provide an alternative to the current food waste management.

1.2 Project Scopes

1. The scope of the project is to develop an IoT-based smart monitoring composter bin based on Bokashi composting method.
2. To evaluate the closeness of the product working principle to the Bokashi composting method.

2 Data Collection and Clustering

The interview on the applicability and some of the knowledge about food wastes handling toward the targeted community was carried out by Google survey. In the survey form, there are 11 main questions about food wastes handling and Bokashi method of compost and 1 question to classify which categories of the respondents belong to. Overall, from the survey, the results of the responses were classified into three categories:

1. The profile of the respondents and how they handle daily food wastes.

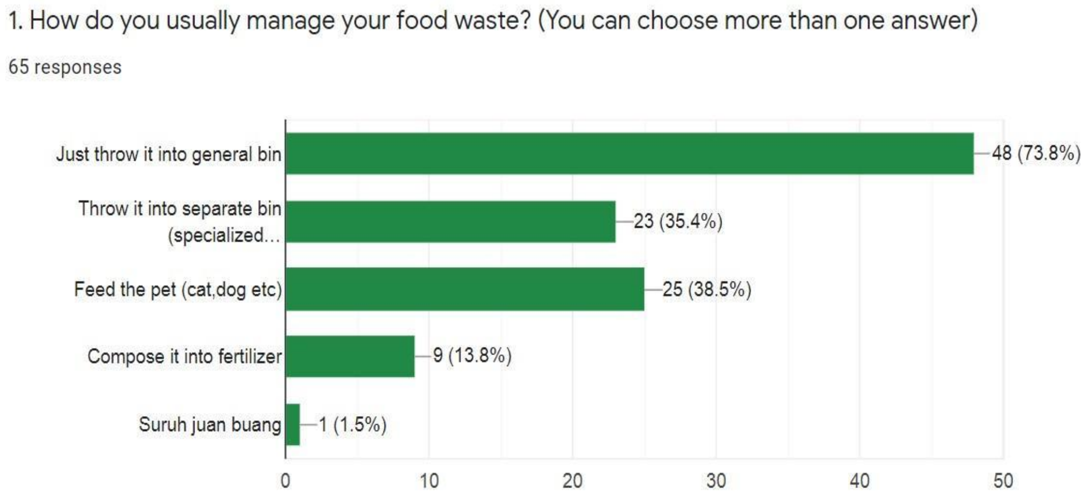

Figure 1: How the respondents manage their food wastes

2. The respondents' knowledge about the mishandling of food wastes.

Figure 2: The common responses from respondents about the mishandling of food wastes

3. What specifications the respondents respect and desired for the Bokashi method composter of food wastes.

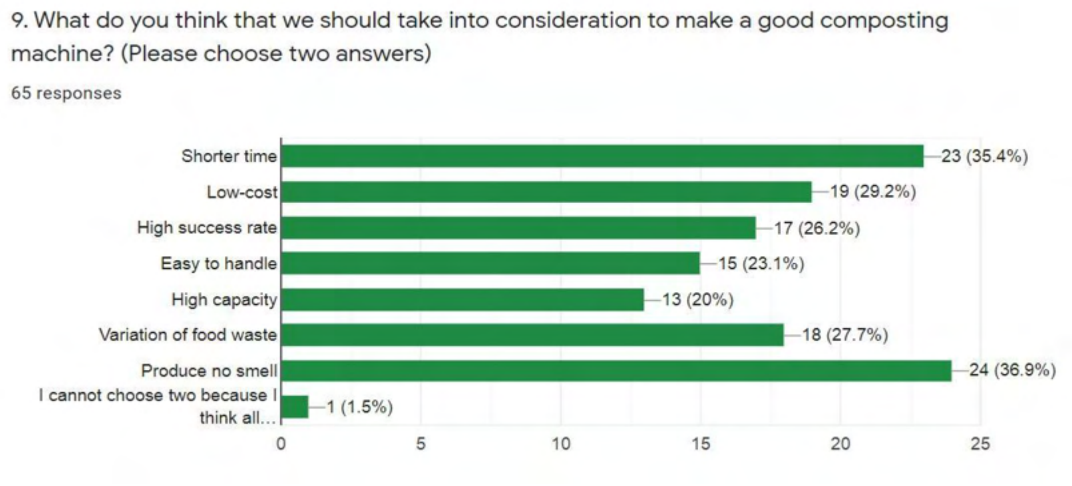

Figure 3: Respondents' views about commercialise values of the desired composting machine

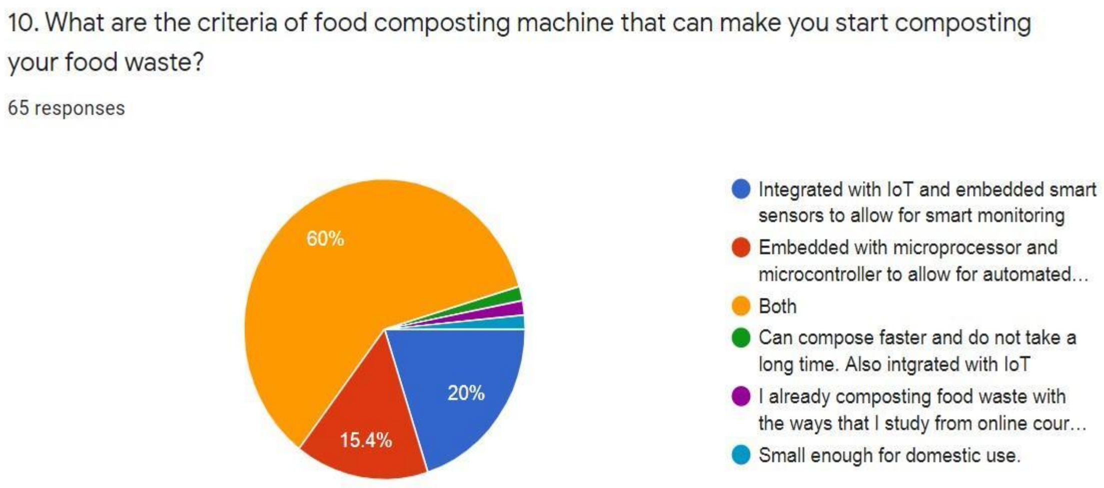

Figure 4: Specifications of the composting machine suggested by the respondents

The data collected was classified with the consideration of the criterions of STEEP Analysis:

"S" for "Social" which the project should be able to raise awareness about food waste pollution to society and encourage people to start composting food waste.

"T" for "Technology" which the food waste composter was embedded with the microprocessor and microcontroller and integrated with IoT and embedded smart sensors.

"E" for "Economic" which the product is convenient to the user can substitute fertilizer with compost, can save money and the product was not only for agriculture but suitable for domestic use too.

"E" for "Environmental" the output of the product could reduce greenhouse gas emission that leads to global warming and climate change.

"P" for "Political" which the design was inspired by said that the treatment of food waste in Malaysia is limited and how to reduce the pile of food waste in landfill thus cutting the cost to manage it.

Summary of the survey, most of the respondents are handling the food wastes by direct throw into the general waste bin and never compost for food wastes but are willing to do so. They also lack knowledge about the mishandling of food wastes.

3 Design statement

From the data collection and clustering, the project design statement to help most of the respondents was how they could easily access the composting process of the food wastes by monitoring and controlling the system with the help of IoT based gadgets.

4 Methodology

This project idea was contributed under a topic: Sustainability System. The food waste composter ideally follows the Bokashi method of composting which Bokashi composting is an anaerobic process that relies on inoculated bran to ferment food wastes, including meats and dairy products, breaking down into a safe soil builder and nutrient-rich tea for the plants.

An IoT based monitoring food waste composter was built up with both hardware and software parts. For the hardware part, it consists of Bokashi bucket and controlling and monitoring electronic system- NodeMCU Esp8266 Wi-Fi module, I2C Liquid Crystal Display, Control Buttons, Servo Motors and Ultrasonic Sensor. While the software part was the user interface with "Blynk" a mobile app that helps to connect the Wi-Fi module to the hardware and it consists of the virtual features on the hardware part to allow the user to control and receive data of the composter at certain distance.

4.1 System Architecture

Figure 5: The system architecture of the final product.

Based on the figure above, we can see that the bokashi bin is embedded and integrated with NodeMCU that is connected to other electronic components. The Bokashi Bin is also connected to a WIFI module so that it can send and receive data from the mobile application, Blynk. The Blynk application has many features that can ease users for Smart Monitoring. Apart from that, users will also be notified with notification alerts from the application.

4.2 Flowchart

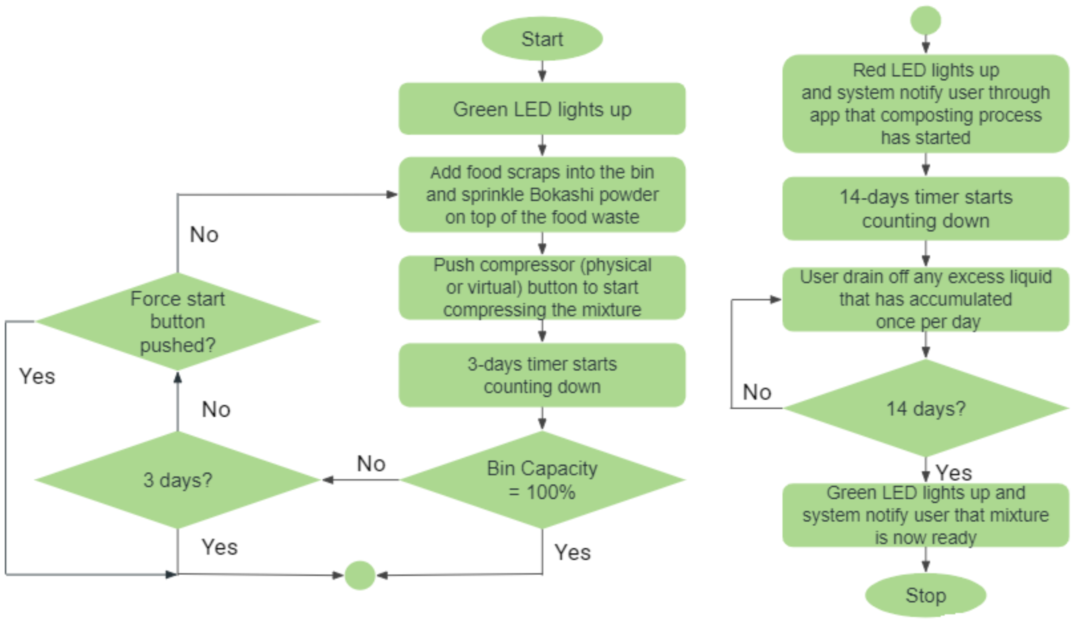

Figure 6: The flowchart of the final product.

The IoT Bokashi composting process started with the users putting the food wastes and Bokashi powder into the bin. The ultrasonic sensor will detect the level of the food wastes together with triggering the compressor to compress the food wastes. The 3-days timer activated, if the bin has not fully filled with food waste the process repeats until the bin is almost fully filled, users also can choose to press the button to start the composting process immediately. After the composting process starts, the alert red LED shows the composting process in progress and at the same time activates the 14-days timer. Users will receive notification to remove excessive composted liquid daily to prevent the bad smell of the compost. After 14 days, the green LED lights show that the compost is ready to be used as fertiliser.

4.3 Block Diagram

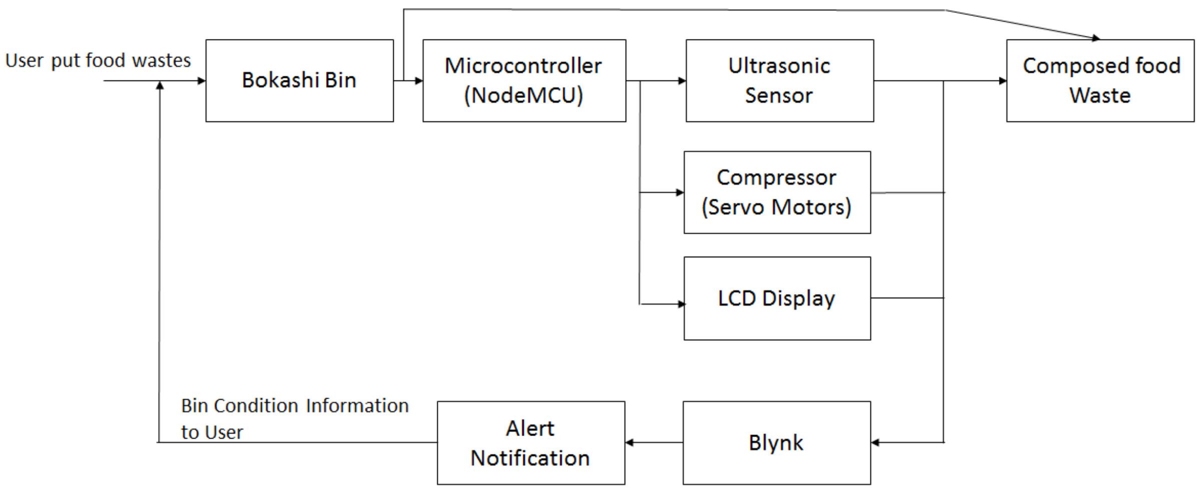

Figure 7: The block diagram of the final product.

4.3.1 ESP8266 NodeMCU

ESP8266 Nodemcu is a low-cost development board for IoT- based applications as shown in Figure 8. It consists of a ESP8266 microcontroller chip which supports in-built Wi-Fi features. Its operating voltage is 3.3V where it can be powered either by using Micro-USB or using external pins. Table 1 shows the datasheet for the ESP8266 Nodemcu.

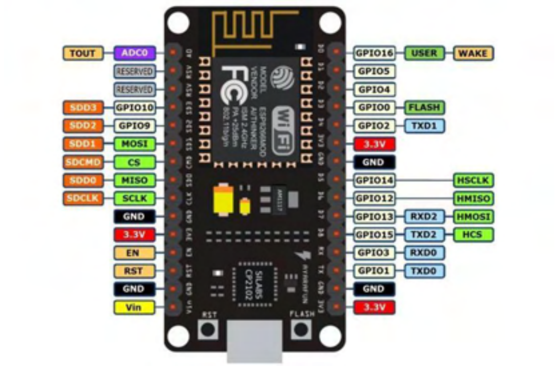

Figure 8: ESP8266 NodeMCU pinout

Table 1: ESP8266 NodeMCU pinout

Microcontroller	Tensilica 32-bit RISC CPU Xtensa LX106
Operating voltage	3.3V
Input voltage	5-12V
Digital I/O pins	16
Analog input pins (ADC)	1
UARTs	1
SPIs	1
I2Cs	1
Flash memory	4 MB
SRAM	64 kB
Clock speed	80 MHz

4.3.2 Ultrasonic Sensor

Ultrasonic sensor HC-SR04 shown in Figure 9 was used in this project. It is used to calculate the distance between the waste level and the sensor by sending and receiving the ultrasonic pulse. The time duration between the sending and receiving of the pulse will determine the distance.

Distance = Duration * speed/2

The datasheet for the ultrasonic sensor HC-SR04 is shown in Table 2 below.

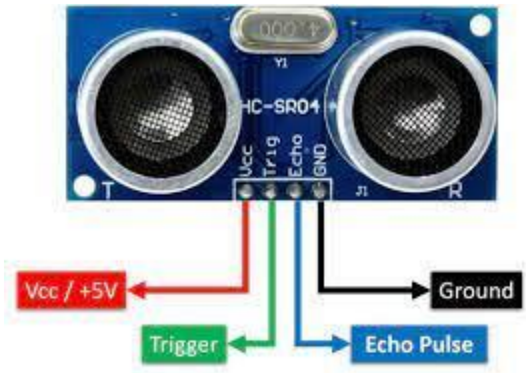

Figure 9: Ultrasonic sensor HC-SR04 pinout

Table 2: Ultrasonic sensor HC-SR04 datasheet

Operating voltage	5V
Theoretical measuring distance	2cm to 450 cm
Practical measuring distance	2cm to 80vm
Accuracy	3mm
Measuring angle covered	<15°

4.3.3 Servo Motor

Continuous rotation (360°) servo motor SG90 was used in this project as shown in Figure 10. It is a rotary or linear actuator which operates based on PWM signals. Table 3 shows the datasheet of continuous rotation servo motor SG90.

Figure 10: Continuous rotation (360°) servo motor SG90

Table 3: Continuous rotation servo motor SG90 datasheet

Operating voltage	4.8-6 V
Operating speed	110 rpm (4.8V). 130rpm (6V)
Operating angle	360°
Stall torque	1.3kg/cm (4.8V), 1.5g/cm (6V)
Dimension	23 x 12.5 x 22mm

4.3.4 I2C LCD 1602

16x2 Liquid Crystal Display (LCD) with inter-integrated circuit (I2C) shown in Figure 11 was used for this project. It is able to display characters in 2 lines where 1 line consists of 16 characters. Implementation of I2C reduces the pins used for LCD display into 4 pins only which are VCC pin, GND pin, SDA pin and SCL pin. The operating voltage is within 3.3 – 5 V. Its size is 80mm x 36mm x20mm with a viewable 66mm x 16mm.

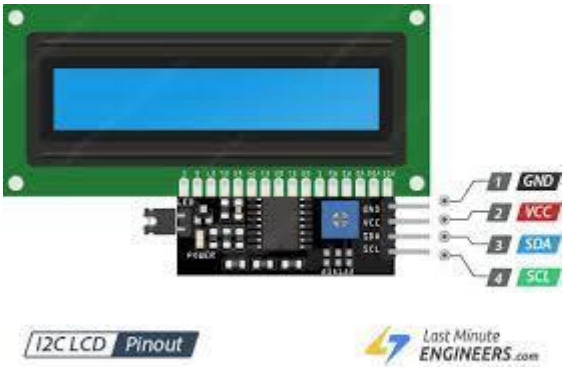

Figure 11: I2C LCD 1602 pinout

4.3.5 Blynk

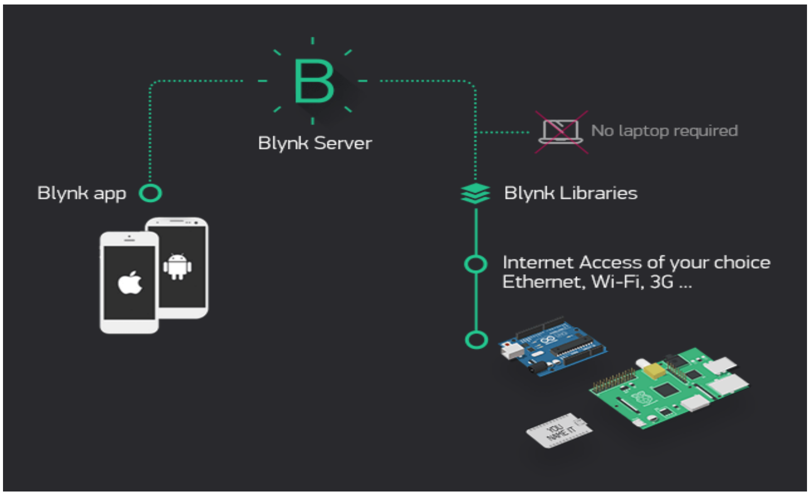

Figure 12: Blynk operation

Blynk is an iOS and Android IoT platform which allows for controlling hardware remotely. It consists of Blynk App, Blynk Server and Blynk Libraries as shown in Figure 12. Blynk App allows users to create their own interfaces, Blynk server is used for communications between the Blynk App and the hardware meanwhile the Blynk Libraries allow for communication with the server. In this project, wi-Fi connection to the cloud was used at which ESP8266 was used as a Wi-Fi module.

4.4 Schematic Diagram

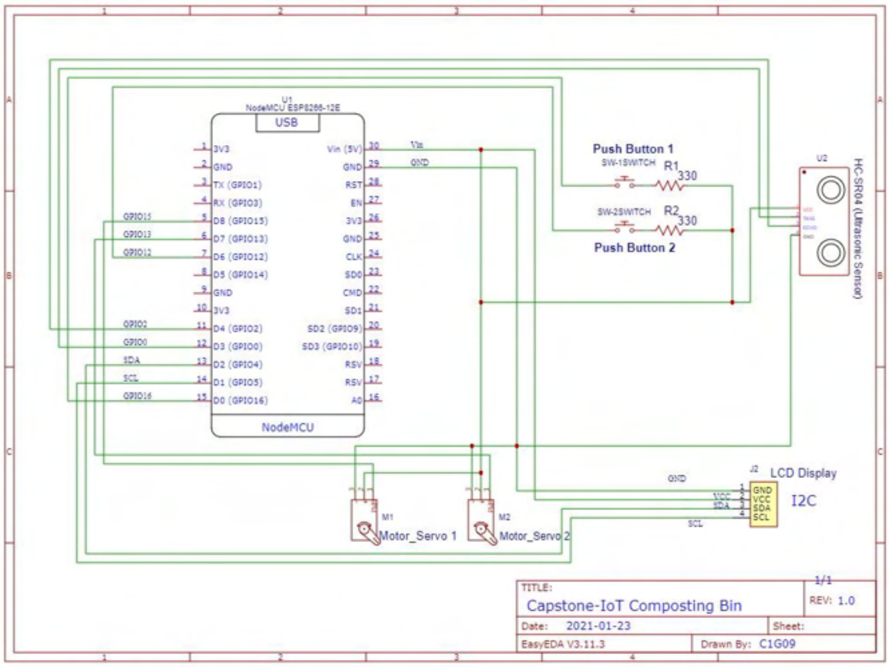

Figure 13: The schematic diagram of the final product.

5 Product Development

5.1 Gantt Chart

Table 4: Gantt chart for the product development process.

Task / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Design thinking process	/	/													
Data collection			/	/											
Design conceptual prototype					/										
Purchase project material						/	/	/	/	/					
Design improvement							/	/							
Software development							/	/	/	/					
Hardware development								/	/	/					
Assembling and programming								/	/	/	/	/			

Test the final product	/		
Do fine tune	/		
Present the final product		/	
Submit technical report			/

First 5 weeks of the project were for conceptual prototype design. After our design has been approved, the actual prototype development first started with design improvement. At first, we decided to use Arduino Uno as microcontroller board and ESP8266-01 as the Wi-Fi-module. After further discussion, ESP8266 Nodemcu was picked as the microcontroller and also the Wi-Fi-Module as it helped to reduce the cost of developing 1 final product and it is easier to be connected to Blynk without updating the firmware to the latest version. After completing the assembling and programming process, the testing phase started where we tested several features such as the accuracy of the timer, accuracy of the smart compressor and the effectiveness of power supply to ESP8266 module.

5.2 Bill of Material (BOM)

Table 5: The Bill of Material (BOM) list of the final product.

Components	Unit Price (RM)	Quantity	Subtotal (RM)
Bokashi Bin	64.00	1	64.00
ESP8266 NodeMCU	18.50	1	18.50
HC-SR04 Ultrasonic Sensor	3.90	1	3.90
Servo Motor SG90 360 Degree	6.90	2	13.80
I2C LCD 1602	9.50	1	9.50
3D Printing Service	35.38	1	35.38
Adapter Power Supply	15.00	1	15.00
Breadboard	4.50	1	4.50
Others	20.00	1	20.00
Total Cost (RM)			**184.59**

Table 5 shows the BOM list of the final product. The list comprises all the components used to build 1 final product. Due to overlapping of several components such as extra ultrasonic sensor, ESP8266 Nodemcu, servo motor and LCD display, the actual cost became RM 361.46. This overlapping of components occurred as the team members were developing this product from different places. 'Others' in the table comprises the jumper, resistor, led and push button.

5.3 Final Product

Due to some issues on the main prototype, we could not use the Bokashi Bin. We came with another alternative which was to use a back-up prototype. Hence, a regular bin is used to replace the Bokashi Bin. The LCD display used also a 2004 LCD instead of 1602 LCD. However, the 20x04 LCD was set to operate just like 16x02 which meant that only 2 lines of character were used. Main prototype is shown in Figure 14. Figure 15 and Figure 16 show the final product of our project. The height of the bin is 20 cm and the distance of the colander inside the bokashi bin to top of the bin is 15 cm. Hence, 12 cm was set to be the maximum height of food waste (capacity).

Figure 14: Main prototype

Figure 15: Top view of the product

Figure 16: Front view of the product

The back-up prototype worked just the same as the proposed design on the main prototype. Figure 17 below shows the circuit connection placed on top of the bin. 2 servo motors were placed in parallel with each other to get better stability of the compressor plate. Figure 18 shows the side view of the servo motor with 3D printed bracket, gear and pusher. The pusher length was set to 15 cm to fulfil the maximum distance available inside the bin so the compressor plate can reach the lowest level of food waste. The design of 3D printed components used for the compressor was inspired by Thingiverse.com, P. (2018, October 28) where the full design specification is available in the Appendix.

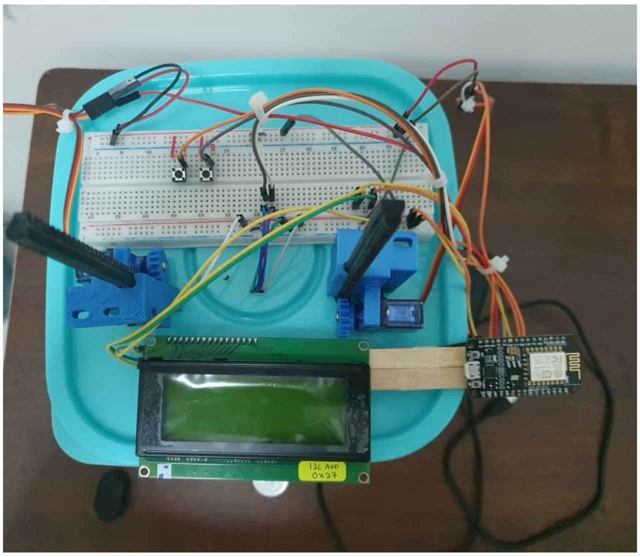

Figure 17: Circuit connection from top view

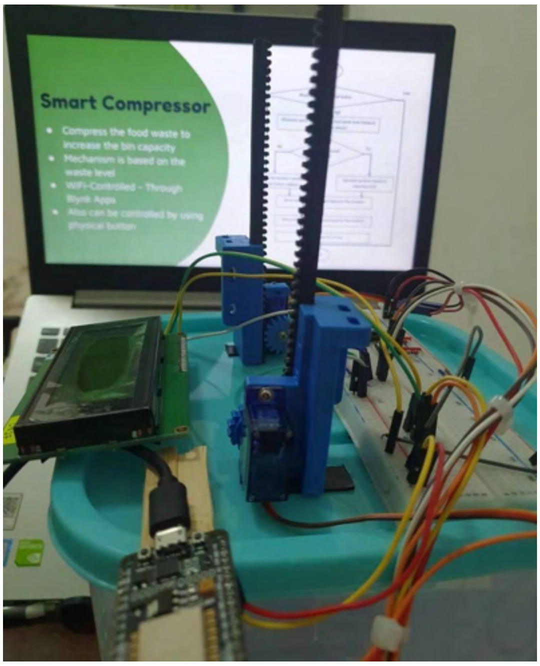

Figure 18: Side view of servo motors with 3D printed bracket, gear and pusher

The servo motors and compressor plate were attached together and its initial position was set as shown in Figure 19. The ultrasonic sensor was placed next to the compressor plate to avoid it from being hit by the compressor plate during the compression process.

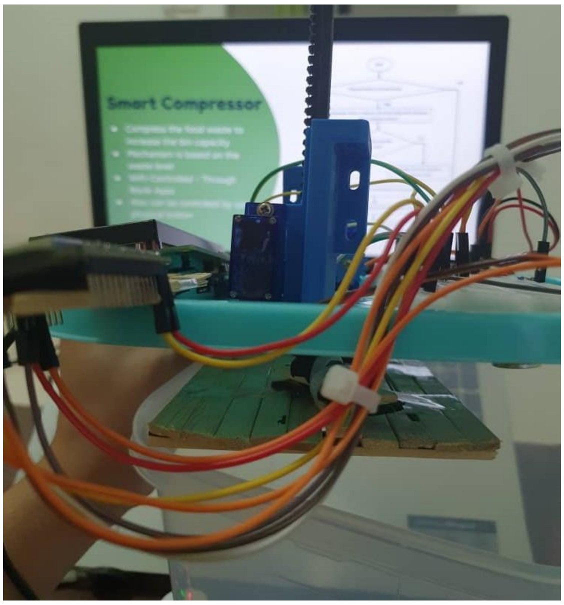

Figure 19: Side view of compressor

Figure 20: Bottom view of compressor plate and ultrasonic sensor

Figure 21 shows the Blynk App interface for the project. It has several widgets which each widget represents a different function. It comprises the 2 virtual push buttons, 2 led, waste level indicator, LCD display and notification alert.

Figure 21: Blynk App interface

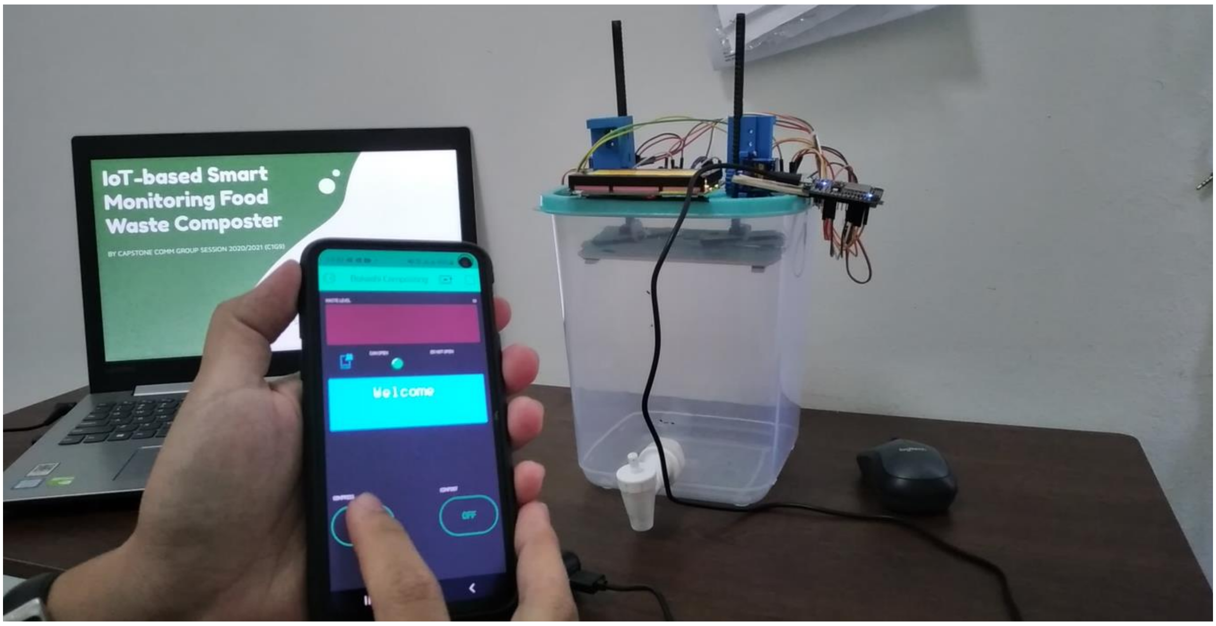

Figure 22: When bin is empty

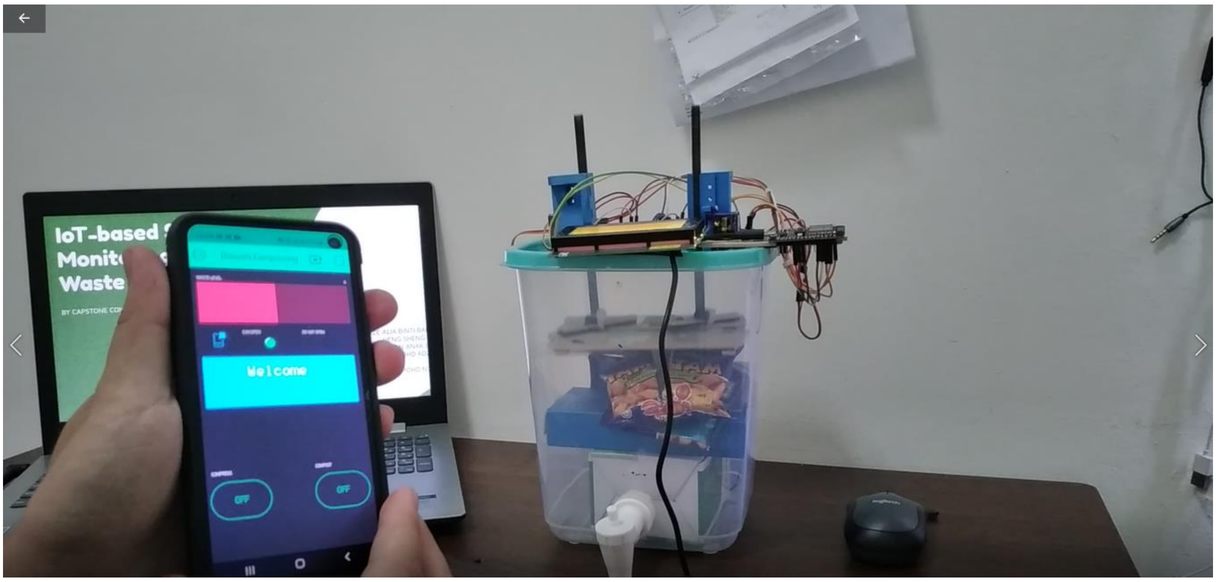

Figure 23: When bin is not empty

5.4 Troubleshooting

5.4.1 Servo Motor Rotation Time Measurement

The operation of the servo motors on the hardware was having the delay when rotate up or down after the detection of the waste level. A calibration was done to estimate the delay time for the servo motors as shown in the table x below which was approximately 100 ms for every centimetre of motion.

Table 6: Approximate Delay of the Servo Motors Rotation

Distance range (cm)	Approximate servo motor rotation time (ms)
4	400
8	800
12	1200

5.4.2 Power Supply Selection

Since the hardware consists of quite a lot of electronic components and each component has its own optimum and maximum operating voltage and current. Overall, except NodeMCU, the other components need around 5V to function properly. There are two tests done for the power supply selection for the hardware as shown in the figure x for 5V adapter without regulator and figure x for 12V adapter with regulator. And why the chosen option is the 5V adapter without regulator because the components are sharing the same input voltage from the Wi-Fi module. Although the voltage output from the 5V adapter without regulator is not stable, when it is supplied to each component the voltage is optimum. While if the regulated voltage is chosen, the voltage supplied is lower and the operation of the components is not optimum.

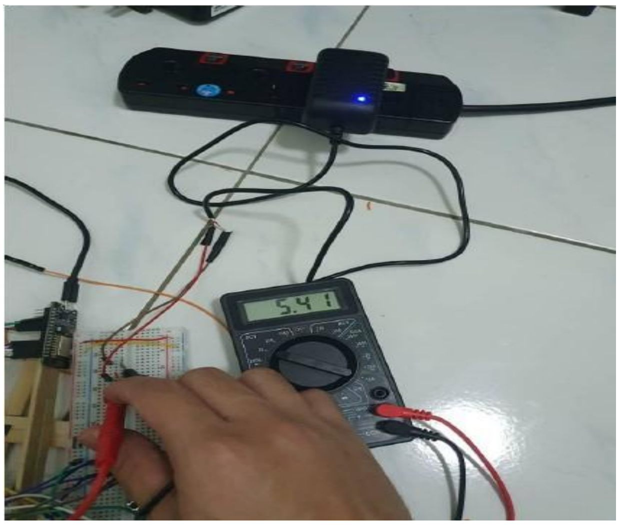

Figure 24: Test of Voltage Output from 5V Adapter without Voltage Regulator

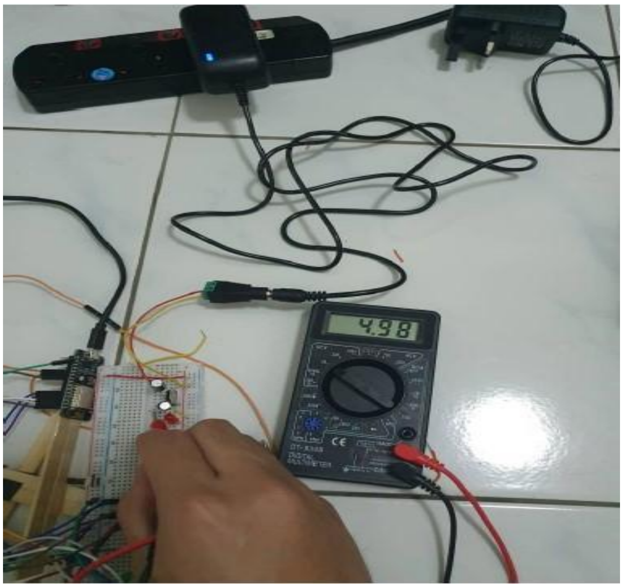

Figure 25: Test of Voltage Output from 12V Adapter with Voltage Regulator

5.4.3 Timer Calibration

During the testing phase, the system timer is compared with the real clock timer to evaluate the accuracy. We tested to run both timers at the same time for 1 minute and found out that the system timer ends 10 seconds later than the real clock timer.

Figure 26: The testing to evaluate the system timer accuracy.

Therefore, to improve the accuracy of the system timer, we calibrate the timer by applying this calculation:

1 min = 1 min 10s => 7/6

14 days = 20160 mins => 23520 mins

23520 - 20160 = 3360 mins

= 2 d 7 hr 12 min

New timer for 14 days = 14 d - 2d 7hr 12min

Thus, to make sure that the timer ends exactly after 14 days, the timer for 14 days is set to: S = 0, M = 48, H = 13, D = 11.

6 Discussion

6.1 Level Detector via Ultrasonic Sensor

The ultrasonic sensor was used in the hardware to detect the level of the food wastes that had been thrown into the bin. The detected level of the food waste was displayed virtually on the Blynk app with the horizontal level feature with respect distance displayed in unit centimetre at the upper right side of the horizontal bar.

Figure 27: Food Waste Level displays at the Horizontal Level Bar of Blynk

6.2 Smart Compressor with Servo Motor

The compressor was used to compress the mixture of food waste and Bokashi composting powder in order to make sure the powder really mixed with the food waste for a more efficient composting process. The compressor also helped to increase the capacity of the bin by pushing and compacting the food waste. Next, this compressor is a smart compressor where its operation is based on the waste level which is detected by ultrasonic sensors. It will not operate if the ultrasonic sensor detects no food waste on the bin. This compressor is a WiFi-controlled compressor which is enabled by using ESP8266 Nodemcu and Blynk, hence, it can be controlled by using a physical button on the bin or virtual button on Blynk App. The bin has been designed to start the composting process if there is no addition of food waste to the bin after 3 days. Therefore, the virtual compress button on Blynk App was also assigned to resemble the throw in of new food waste to the bin. The 3 days timer will restart every time the virtual compress button is pressed. Meanwhile, pressing the physical compress button will only operate the smart compressor without restarting the 3 days timer.

6.3 Timer

There are two timer functions available in the system in which both functions are placed in the void loop () function but with some conditions. The timer used is based on the delay () function in which 1 second is equivalent to delay (1000). The system will exit the timer function when the timer reaches 0.

6.3.1 3 days timer

The 3 days timer is a timer that is set to avoid miscounting of the composting process duration and to provide the best timing estimation in order to obtain the right final product which is the compost and not an unsuccessful compost. This is how the 3 days timer works:

- This timer will be activated and start counting down after the waste is thrown and the compress button is pressed virtually.
- The timer will then restart every time the waste is thrown until the bin is full.
- The timer will stop counting when it reaches 0 or when the bin is full or when the user presses the force start button, then the 14 days timer is activated.

6.3.2 14 days timer

The 14 days timer is a timer that represents the duration of the composting process. 14 days is the optimum time for the Bokashi composting method to produce a good and nutritious compost. This is how 14 days timer works:

- The timer will be activated and start counting down when the 3 days timer has reached 0 or when the bin is full or when the user presses the force start button.
- The timer will end when it reaches 0.

When the timer ends, the system will exit the timer function and go back to the main loop and wait for signals from the sensor.

6.4 LED Signal

There are two LEDs in this system which are red LED and green LED. This LED signal is integrated in the Blynk application and not available in the hardware part due to the limited number of NodeMCU pins. This is the indications for the LED:

- Green LED : Indicates that the bin is available to accommodate more food waste and the composting process has not started yet or the bin is open for users to remove the compost (after the composting process is complete).
- Red LED : Indicates that the composting process has started and the bin should not be open to ensure that the composting process runs smoothly and high-quality compost is produced.

6.5 LCD Display

In this system, the LCD Display used is the I2C LCD 1602. This is because we wanted to minimize the number of NodeMCU pins used so that there are enough pins for the whole system during the hardware assembling process. The coding for the LCD functions is similar for both LCD 1602 and I2C LCD 1602 except for that the library used is different in which the LCD 1602 uses normal Liquid Crystal library while I2C LCD 1602 uses LiquidCrystal_i2c library. The LCD Display is available on the hardware and also in the application. It is used to display the timer, the status of the bin and for the smart monitoring purposes.

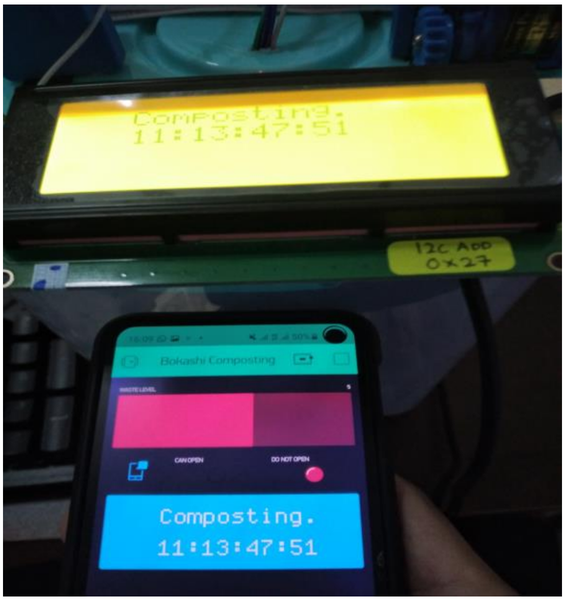

Figure 28: The LCD Display on the hardware and in the application.

6.6 Force Start Button

This button is used for users to force the composting process to start without waiting for the 3 days timer to end or waiting for the bin to full.

6.7 Smart Monitoring via Blynk

In the Blynk application, the Waste Level Indicator and LCD Display are two features that are necessary for smart monitoring. With these two features, as shown in Figure x, users can monitor the level of food waste inside the bin and the remaining time before the composting process ends.

6.8 Notification Alert System via Blynk

This notification alert system is designed to remind or notify users:

- To remove excess liquid from the bin once every 24 hours.
- The composting process has started.
- The composting process has completed and compost is ready to be removed.

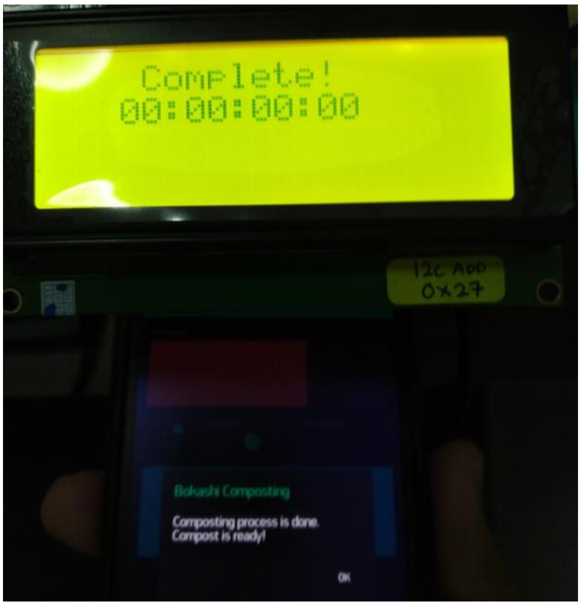

Figure 29: The LCD Display that the timer has ended and the composting process has completed and notification has popped up at the same time to notify users.

Figure 30: The notification alert to notify users that the composting process has started.

Figure 31: The notification alert to remind users to remove excess liquid.

Conclusion

Based on the final product presented, we managed to achieve and complete all the objectives proposed in this project. Firstly, we managed to design a smart compressor system and smart monitoring system by using Arduino and Blynk mobile's application. Arduino plays a very important role as an open-source hardware and software project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and then the bin activities are monitored through Blynk application. Other than that, we are also able to implement the WIFI controlled system by using ESP8226 NodeMCU and Blynk. Since we are using WIFI as a connection, NodeMCU is a very suitable and reliable WIFI module that can be programmed easily with Blynk compared to other WIFI modules. Lastly, throughout the product, we can provide an alternative to the current food waste management. The bin can be placed at the cafeteria, pantries and grocery store at our faculty which can easily be accessed. In other words, we hope this product creation can help people practice to compost food waste easily and help to reduce food waste problems.

Acknowledgement

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Lastly, we would like to appreciate all those that have helped us directly or indirectly towards the completion of this project throughout this semester.

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JANUARY 2021

Reverse Vending Machine

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Abstract: The reverse vending machine is used as a solution to combat waste management issues by focusing on recycling initiative. Based on data collected via survey of Universiti Teknologi Malaysia's staffs and students, surveyees universally agree that by providing incentives, they would be more motivated to participate in recycling exercises. Hence, in addition to developing hardware that segregates and weighs the waste, an App for users to accumulate credit to be cashed out in a number of sundry shops and cafes within the university's campus have been developed.

Keywords: Recycling; Hardware; App; QR code

Introduction

In 2018, Greenpeace Malaysia stated that Malaysia has become the world's rubbish bin. It was reported that Malaysia had taken in 754,000 tonnes of plastic waste from over 19 countries that year. According to the BBC, a town in Kuala Langat, which is Jenjarom is now filled with 17,000 tonnes of waste [1]. BBC also reported that many illegal recycling plants chose to dispose plastic in a cheaper way, which is either burning it or burying it. This had become a health hazard where residents reported to have coughed up blood clot, sleepless nights due to the bad smell, eye irritation etc. This had also caused water and air pollution [2].

Not producing trash at all is not doable in a short time frame. So, the least that can be done is recycle to reduce the amount of new recyclable waste produced. For this Capstone Project, it is proposed, in order to help Universiti Teknologi Malaysia (UTM) in becoming a more sustainable university, recycling habits need to be promoted by providing motivation. UTM's students, lecturers and staff have been asked some questions on their perspective of recycling and their view on a proposed recycle-reward system. Based on survey conducted, among 46.5% of surveyees dispose of recyclable waste together with other wastes even though 97.7% of them agree that recycling is important.

This paper proposed to have this reward system in order to improve recycling rate effectively and 88.4% agreed on its potential effectiveness. The proposal is to have recycling stations with each being the size of common-operated vending machine. The targeted wastes are paper, metal and plastic [3] – [5]. Through this system, it is envisioned that more people would be motivated to recycle their wastes and play a part in saving the environment [6].

Project Objectives:

1. To create a self-regulated recycling station that will generate credits for students or staff of UTM, every time he or she is using the above-mentioned utilities.
2. To nurture students in partaking recycling efforts while keeping the areas of UTM clean from waste.
3. To develop a recycling station that trades to-be recycled waste with credits system based on material type of recycle product and the weight of each item while the credits gained will be transferred to a designed mobile phone's application using the QR Code system.

Data Collection:

1. Project's Target

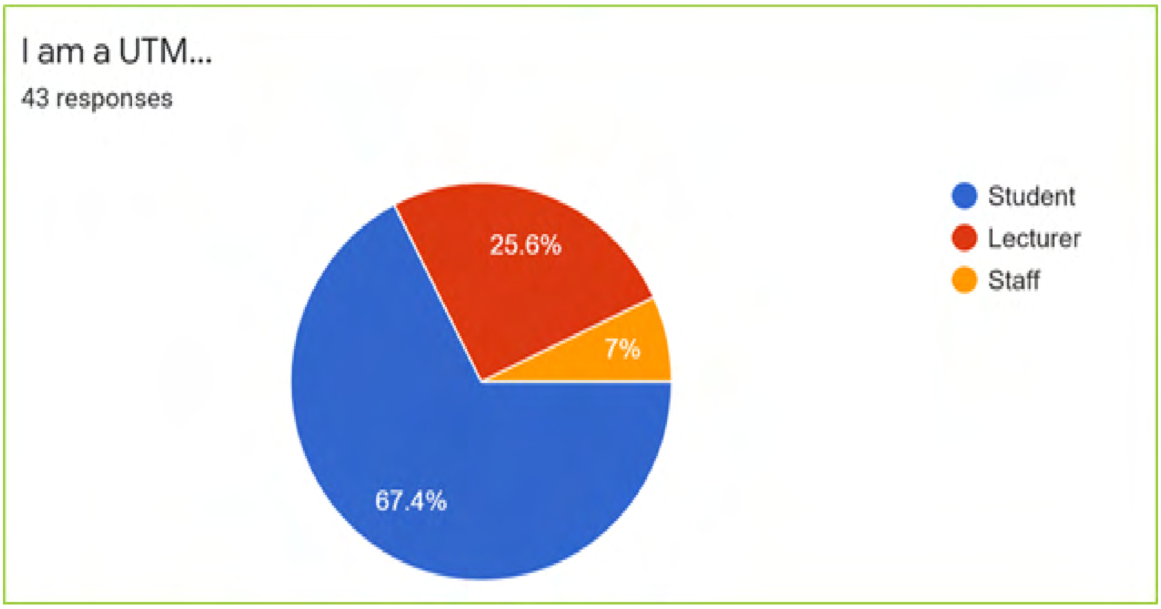


Figure 1.1 Demography of Respondents

Figure 1.1 shows the pie chart of the type of respondents of this survey after blasting it to both the social groups and university group. Majority of the respondents came from the student with 67.4 percent of the 43 total respondents followed by the lecturer at 25.6 percent and 7 percent by the staff.

2. Recycle Product Management

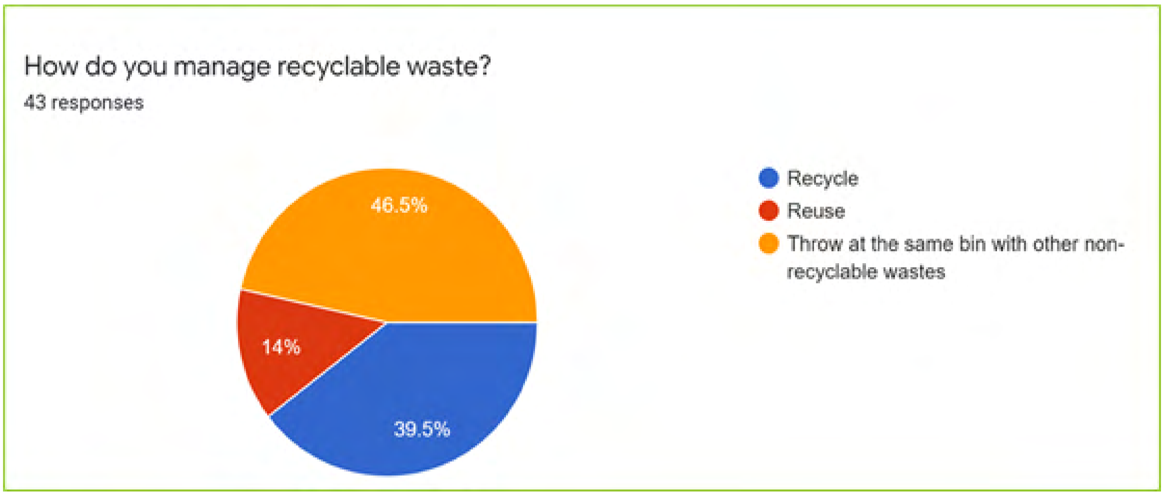


Figure 1.2 Recycle Management of Respondents

The Figure 1.2 shows in terms of recycling product management most respondents at 46.5 percent directly rid all their waste products to a single bin. This is more likely to show how simple and straightforward the procedure is to the respondents. Other majority of the respondents at 39.5 percent choose to recycle their product diligently and only 14 percent choose to reuse the recycled waste.

3. Opinion of the Impact of Waste Management

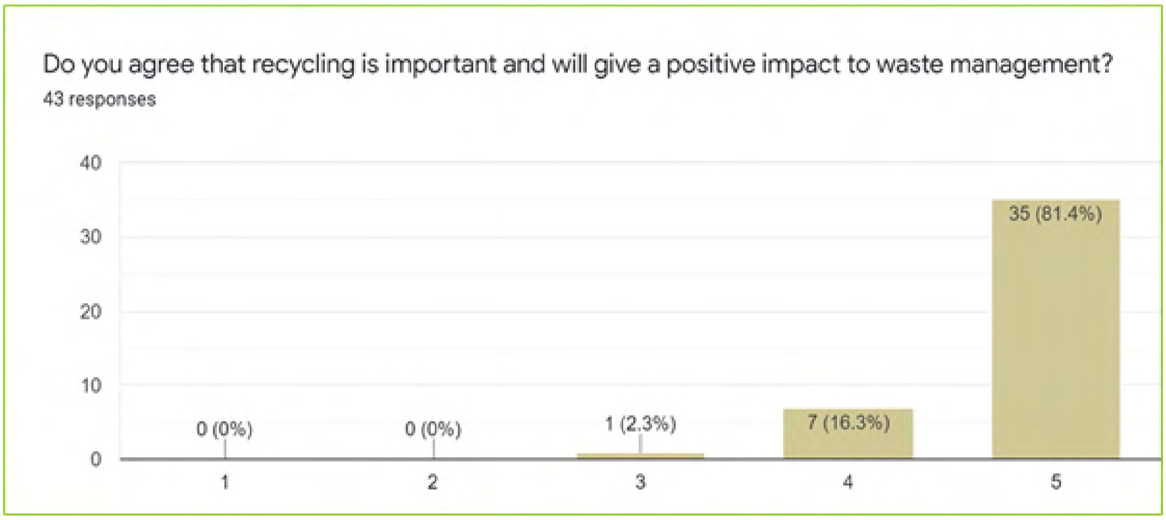


Figure 1.3 Respondents' opinion on importance of recycling

From Figure 1.3, it clearly shows that most of the respondents agree that recycling is important and will give a positive impact to either society or environment while one respondent had a mixed response to the questionnaire.

4. Recycle Activities Management

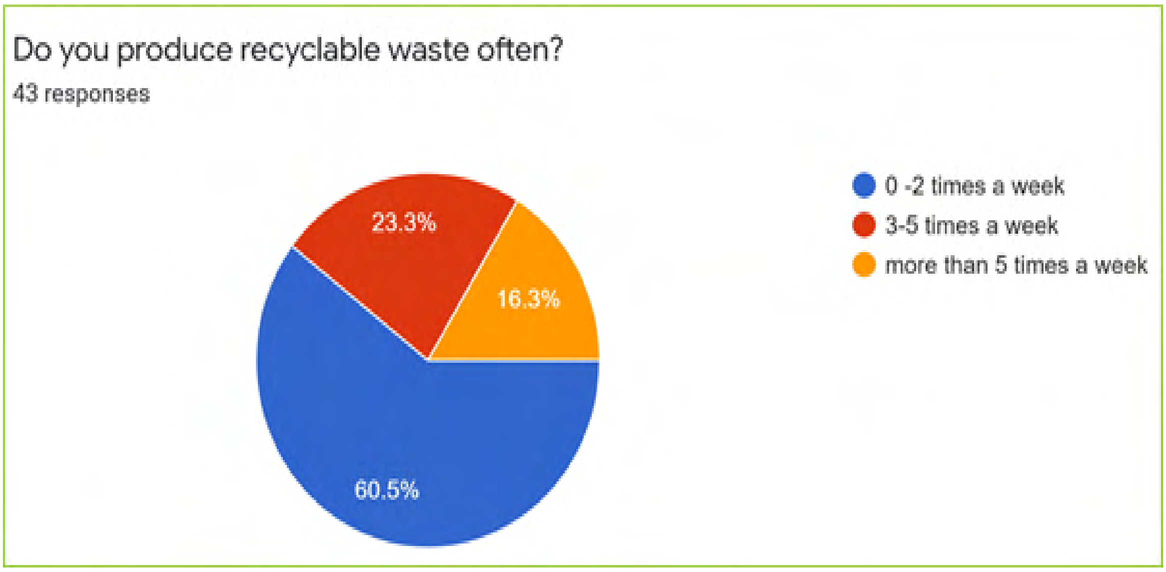


Figure 1.4 Recycling habit of respondents

Figure 1.4 shows that the respondents that do recycle vary from the number of times they recycle within a week. Most at 60.5 percent respondents only recycle about two times a week while another 39.6 percent produce recycled products from three to more than five times a week.

5. The Rating of University's Effort in Recycle Management

Figure 1.5 Respondents' rating on university's recyclable waste management

From Figure 1.5, it can be safely said that most of the responses have a mixed response to the effort by the university in managing recycling products while the rest either have a high rating or low rating to the university's effort.

6. Respondents 'Response on Recycle-Reward System

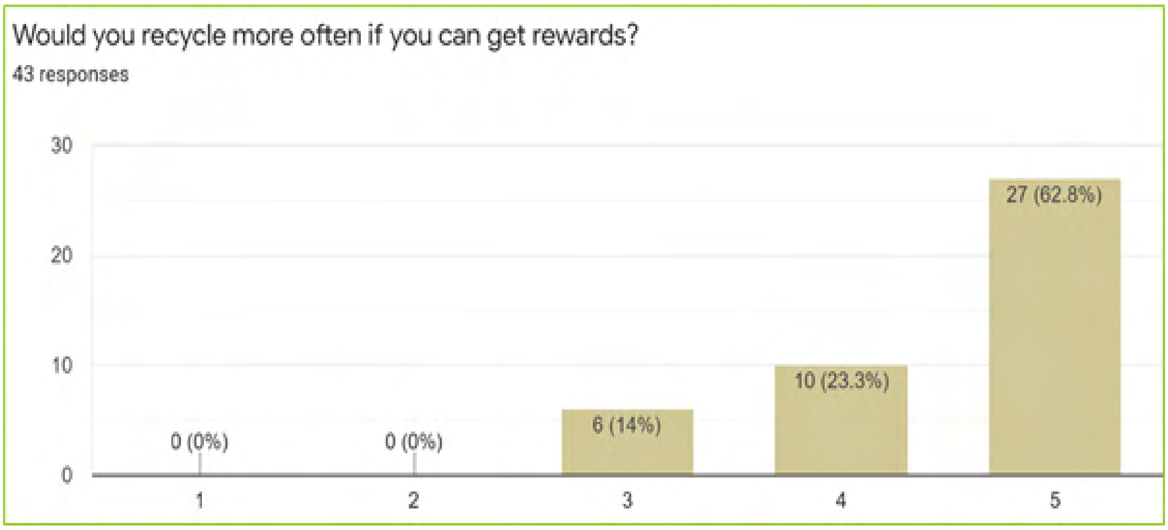


Figure 1.6 Respondent's response to recycling having a reward system

As shown in Figure 1.6, majority of the respondents agree that the reward system will encourage them to recycle often while the other six respondents have a mixed response to this system.

7. Respondents 'Opinion on Reward System Effect on Improving Recyclable Product Management

Figure 1.7 Respondents' opinion on the impact of reward system to university's recyclable waste management

Similar to the previous questionnaire, Figure 1.7 shows that most of the respondents show a unified response that the reward system will contribute in improving recyclable waste management effectively while other respondents have a mixed response on this reward system effect on waste management.

8. Respondents' Reward Preferences

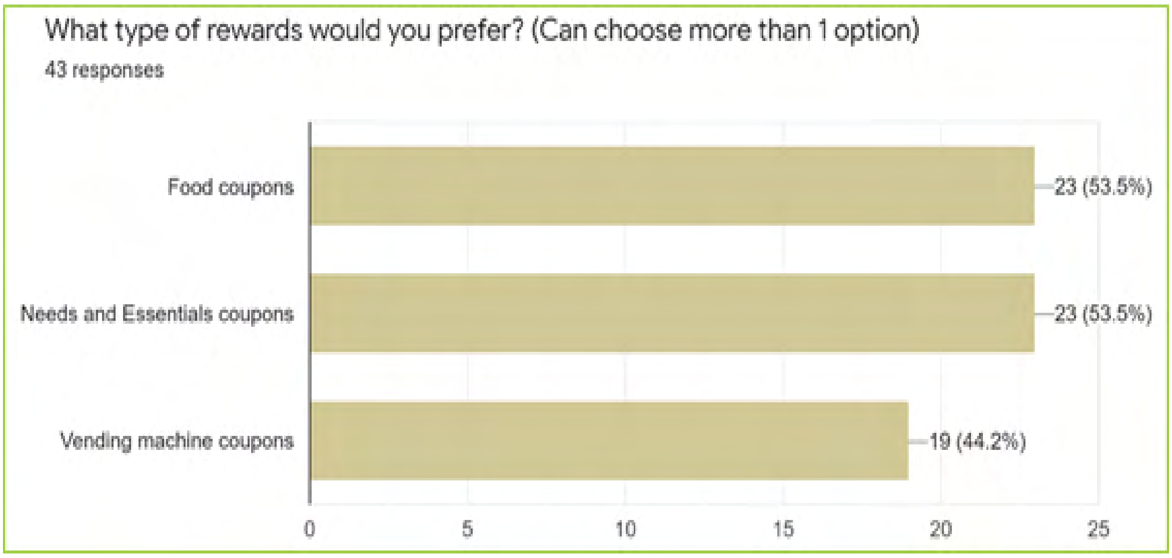


Figure 1.8 Respondents' preferences on type of rewards

Based on the questionnaire's responses as in Figure 1.8, 46 respondents agree the points that they accumulated from the recycling should be redeemed to either food coupons or need and essential coupons while the other 19 respondents want to redeem the vending machine coupons.

9. Reverse Recycle Machine Spots Allocation

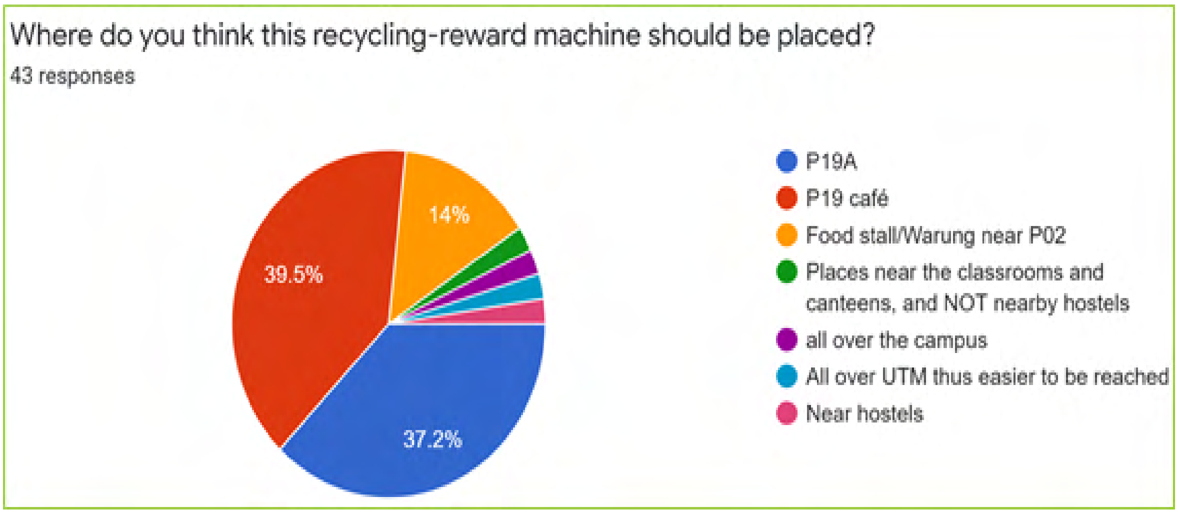


Figure 1.9 Respondent's opinion on the location of the machine

Figure 1.9 shows preferred recycling machine spots allocation. About 39.5 percent of the respondent agree that the machine be placed in P19 café while the other 37.2 percent said it should be located at the main faculty block (P19A) and 14 percent others want the machine to be placed nearby food stall near block P02. The other minorities want the machine either near the classroom for easy access or near the hostel or all over the UTM.

10. The Project's Machine in Inconvenience Place Near the Office of the Faculty

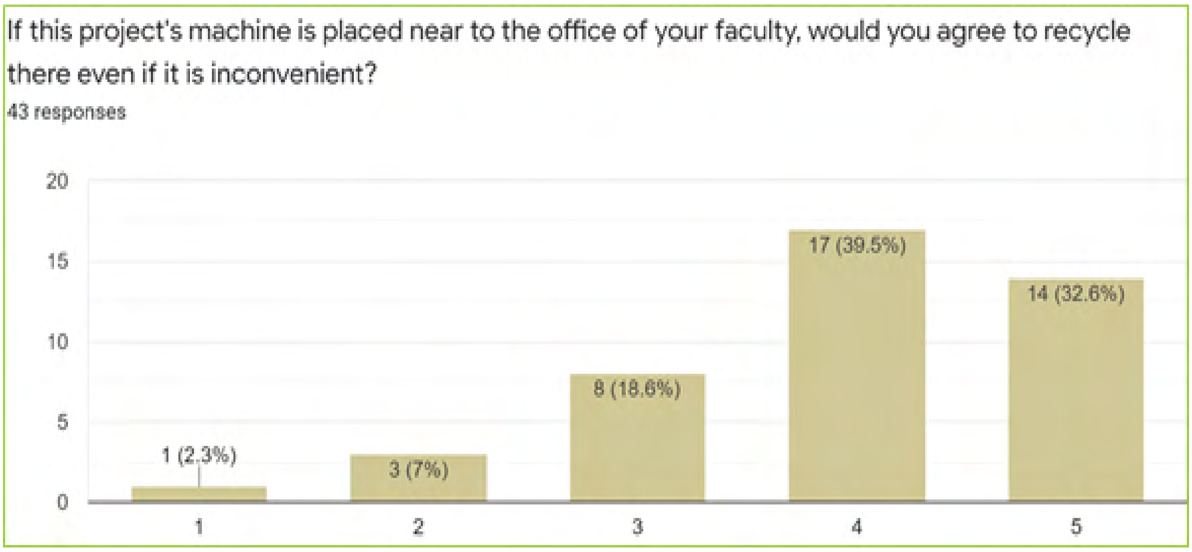
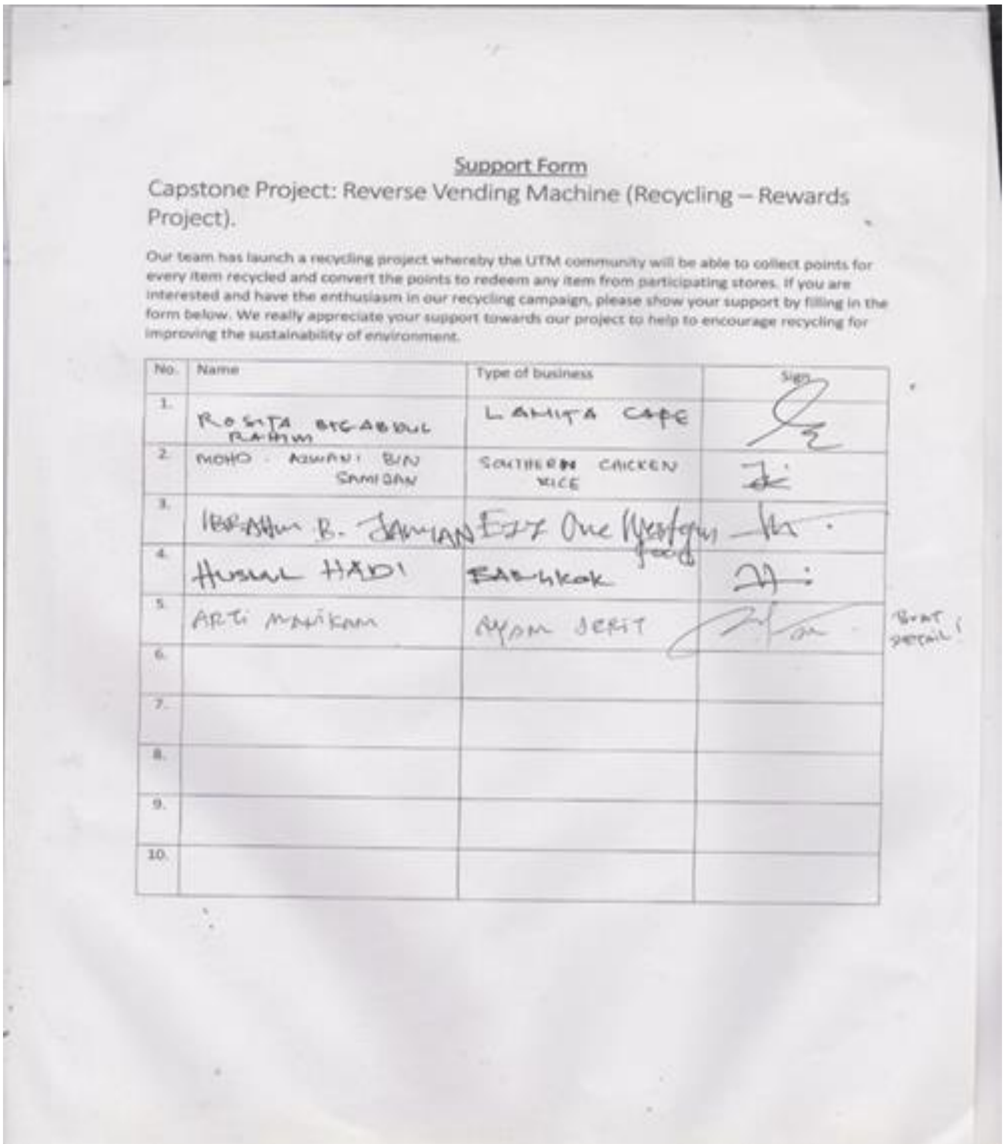


Figure 1.10 Respondents' opinion on the hypothetical location of the machine

Based on the survey's responses as in Figure 1.10, if the machine is located near the office block, 31 respondents agree that they will still recycle showing that the recycle-reward system is worthwhile for them despite the inconvenience. Meanwhile, eight respondents have a mixed response on this survey while other four respondents protested that it is inconvenient for them to recycle with the machine located far from them.

11. Support from the Shops and Cafés Owners of UTM on this Project



Support Form

Capstone Project: Reverse Vending Machine (Recycling – Rewards Project).

Our team has launch a recycling project whereby the UTM community will be able to collect points for every item recycled and convert the points to redeem any item from participating stores. If you are interested and have the enthusiasm in our recycling campaign, please show your support by filling in the form below. We really appreciate your support towards our project to help to encourage recycling for improving the sustainability of environment.

No.	Name	Type of business	Sign
1.	ROSITA BTE ABDUL RAHIM	LAMITA CAFE	[illegible]
2.	MOHD AZWANI BIN SAMIDAN	SOUTHERN CHICKEN RICE	[illegible]
3.	IBRAHIM B. JAMIAN	Ezz One Western food	[illegible]
4.	HUSNUL HADI	BANGKOK	[illegible]
5.	ARTI MANIKAM	AYAM JERIT	[illegible]
6.			
7.			
8.			
9.			
10.			

Buat detail

Figure 1.11 Responses from Cafe and Shop Owners in the university on their opinion of this project

It was originally planned to conduct interview with owners of shops inside UTM's campus on the significance of this proposed project and gaining their opinion and support. However, due to Covid-19 of 2020 epidemic, most of the shops were closed during the Movement Control Order (MCO) in Johor to avoid further spread of the virulent disease thus limiting interview to a few shops that were still opened. From the 10 shop owners that have been interviewed, half of them agree that the system will benefit both the students and owners of the shops as they fully realise the potential of this project to their shops' economy as shown in Figure 1.11.

Design Statement

Improvement of university waste management by providing recycling machines at most accessible places such as P19 café that give rewards when users recycle items. The rewards can be collected and be used to redeem needs and essential coupons in collaborated stores in the UTM premise. This will help create awareness and cultivate motivation for recycling. At the same time, it will help reduce the targeted user expenses.

Methodology

1. Each member was to come up with ideas on the project title and had to present it to other team members and project's supervisor.

2. discussion on advantages and disadvantages of every idea to narrow down to one project title via Jamboard was conducted.

3. Project title chosen: Reverse Vending Machine.

4. Google form was developed to collect data on user's opinion and expectation regarding this project.

5. The data obtained from Google Form response was clustered.

6. By collection and clustering of data from Google Forms, the targeted users, concept, functions and objectives of this project and materials needed to develop the project's prototype were identified.

7. All the possible functions were narrowed down for this proposed application and prototype.

8. The conceptual prototype was presented to panels and comments from them were taken to improve the project.

9. The project was started with application development. *Thunkable* software was used to develop Android-based application [7] and Firebase was used for application's database [8].

10. After application development was completed, the application was tested and troubleshot for errors.

11. Prototype development started after the application development was completed. It was started with programming the hardware using Python [9] while waiting for all the hardware components to arrive.

12. After coding was completed, the hardware's soldering works was initiated.

13. the components for hardware was assembled to test out the functionality of the coding.

14. Unfortunately, the weighing sensor that was ordered was not functioning. Since the weighing sensor is the major component for this project to work, the hardware preparation could not be proceeded.

15. As an alternative, simulation work using suitable software was prepared to show the functionality of the hardware.

16. After simulation was done, the project was tested by combining the functionality of the application and software simulation that have already developed.

17. Troubleshooting of the prototype was done to eliminate any errors.

18. A prototype presentation was held to demonstrate the project's functionality to panels [10].

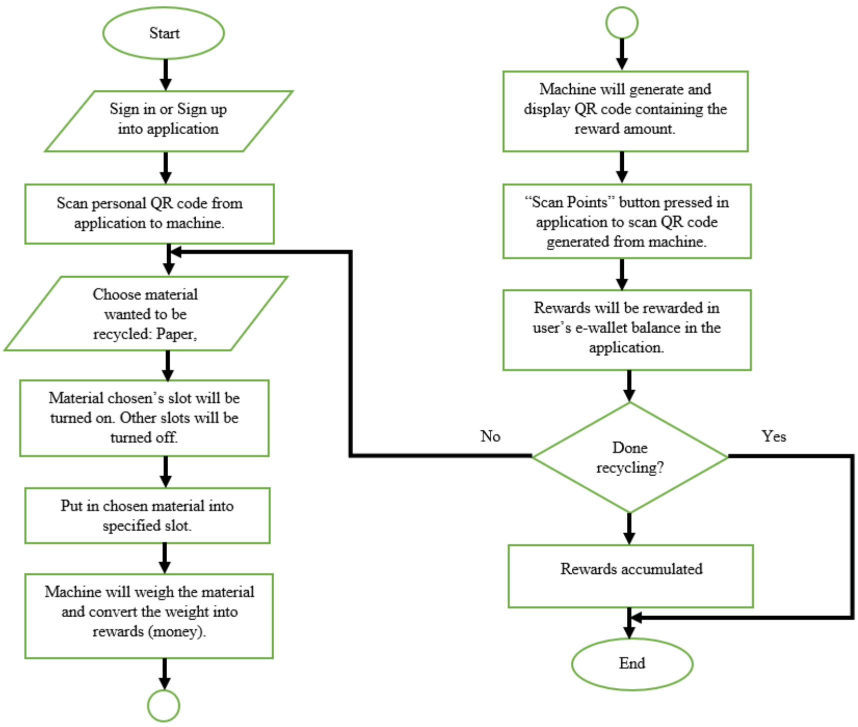


Figure 1.12 Flow chart of the machine and users' experience

Product Development

1. Ideation

The initial step of any project is finding the product idea that will give a positive impact. Each team member was tasked with researching ideas for project products that have the main aspect of a sustainable system for the faculty. For this idea processing phase, IDEO 7 brainstorming rules were applied where a lot of ideas were listed such as smart meters for utility electricity, automation water flow for broken pipelines, lighting automation and reverse vending machine for recycling. The discussion on the project product idea was through a process where each of listed ideas were discussed in details of the product such as the product mechanism, feature, target user and needed materials for the building the product.

As further discussion by the group members, the project of a reverse vending machine for recycling where the user can receive rewards in return of recycling. Based on discussion, the targeted users for the reverse vending machine are students and lecturer and staff of faculty. The mechanism of the system is the user will receive rewards in terms of credits that can be transferred and stored into a designed mobile application using the quick response code (QR code) after recycling at the reverse vending machine. The reverse vending machine will convert the weight of the recycling into e-money as a reward.

2. Product Validation

Product validation is a process where data collection was done on targeted users and future cooperation parties such as owners of food stalls and convenience stalls. Product validation is important to ensure that the reverse vending machine will receive great response in terms of application of the product in the future. For this validation process, a survey was done by sending out an online survey to get feedback from the target user. The questions of the survey were constructed in order to get feedback data of users on the current situation of recycling, the effectiveness of the reverse vending machine, preferable rewards, user problems and needs for recycling, and preferable placement of reverse vending machines. Other than that, the product validation also was done by asking the shop's owner opinion on the reverse vending machine.

Based on the data collection from the survey and interview with the shop's owners, the profiling of a general user containing the user's profile, needs and problems were done using the data clustering technique to categorise the collected data as shown in Figure 2.1. The identified data of paint points and needs from the product validation are lack of motivation for recycling and a need for a recycle system that would effectively improve the recycle waste management and are also easily accessed by the user. Then, based on the user's profile, a design statement can be done where it is used in improvement or changing of reverse vending machine prototype design.

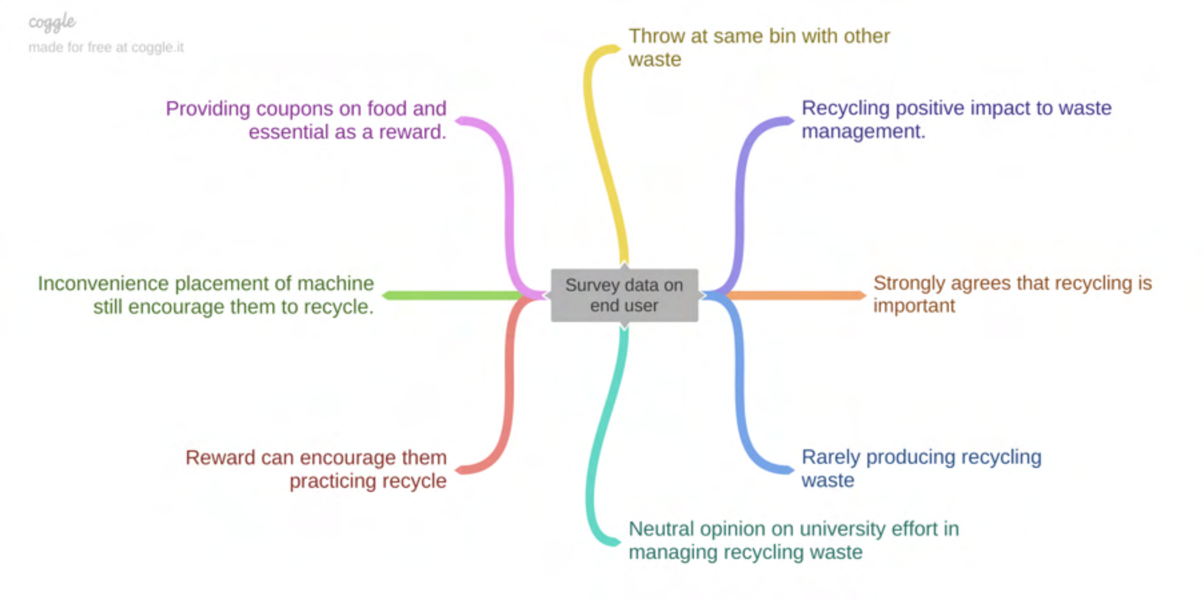


Figure 2.1 Summary of Survey

3. Planning phase

The planning phase of the project consists of the flow in designing the conceptual prototype. The planning of reverse vending machine prototype design and the features were based on the steep analysis approach. The prototype of a reverse vending machine is designed in order to fulfil the purpose of the design statement where the machine can be connected to the design mobile application. Hence, a machine design that can ease the user recycling process where rewards can be credited into the user account in the App.

In this phase, the process of the user using the reverse vending machine for recycling was planned. The figure below shows the conceptual prototype that illustrates the overview of the reverse vending machine. Based on the process, the features needed for the functionality of mobile application for the product have been listed. As a conclusion for the planning phase, the main function needed in the product prototype is such as a weighing sensor system, a manual selection system for choosing the material type of recycled item, QR code display and QR code scanner as shown in Figure 2.2 and 2.3. The type of recycle material and its reference value for conversion of recycle material into value of money was also research on this phase. The price rates are as follows:

Cardboard	=	RM0.20/kg
Magazines	=	RM0.20/kg
Newspaper	=	RM0.20/kg
Plastic	=	RM0.10/kg
Tin/Metal	=	RM0.20/kg
Aluminium	=	RM2.50/kg

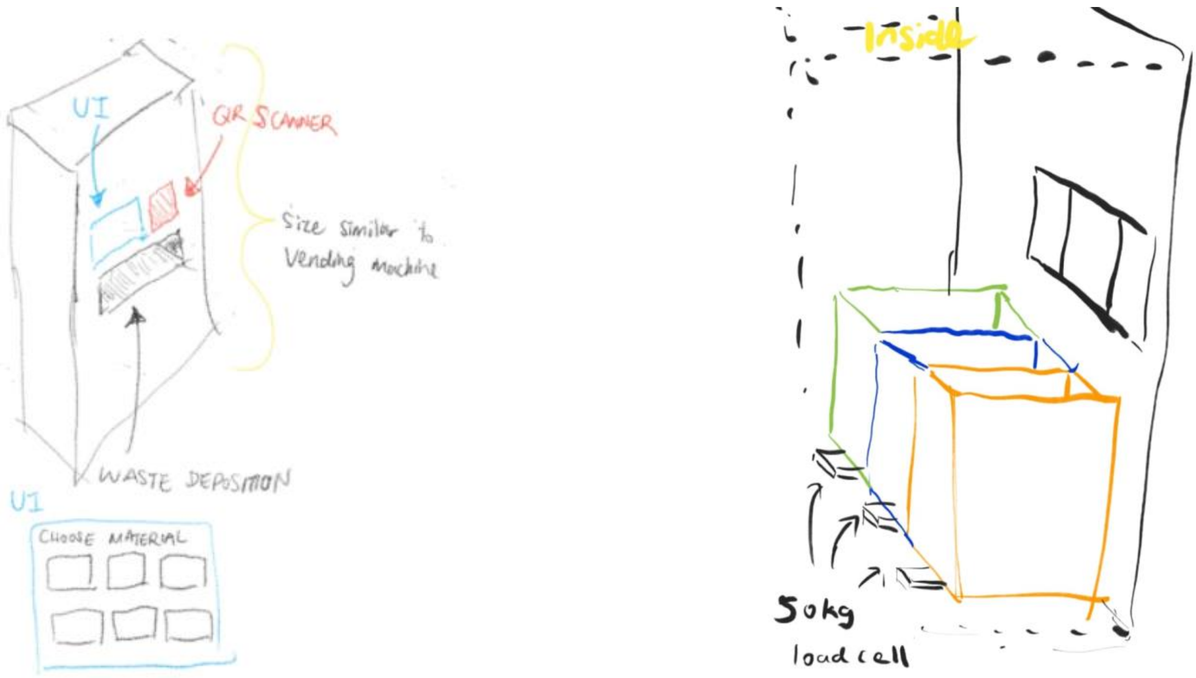


Figure 2.2(left) Exterior view of the vending machine with a user interface (UI) (right) interior view of the machine

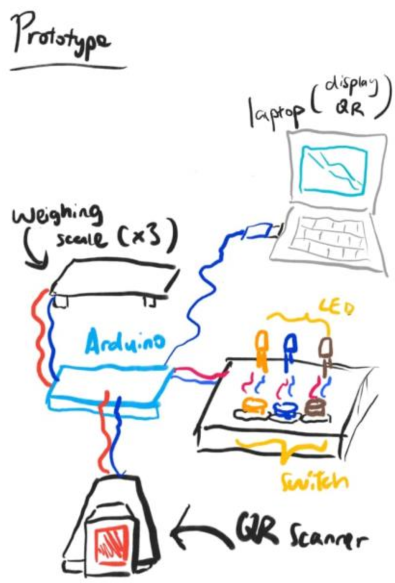


Figure 2.3 Prototype of the Reverse Vending Machine

4. Costing

The cost of producing the reverse vending machine prototype was conducted mainly on purchasing the hardware components such as the weight sensor, QR scanner, switch, Light emitting diode (LED), wire, circuit board and etc. The components were listed based on the requirement components to implement the functionality of the reverse vending machine. The costing for the prototype is needed to be below the allowance provided which is RM300. Hence, the bills of material for costing is important in order to limit the expenses for hardware component purchase. The following table 1 is the expenses throughout this project.

Table 1 Budget and actual cost of project

No	**Component**	**Estimated Cost**			**Actual Cost**	
		Unit Price (RM)	**Qty.**	**Subtotal (RM)**	**Purchased Price (RM)**	**Delivery Week and Remark**
1	ESP32 Development Board	18.20	3	54.60	47.70	Week 8
2	ESP32 CAM	19.40	1	19.40	19.10	Week 8
3	50kg Load cell	17.31	3	51.93	14.70	Week 8
4	HX711 Reader Module (for load cell)	4.90	3	14.70	14.70	Week 8
5	LED bundle	4.13	1	4.13	4.13	Week 8
6	Switches (on/off)	0.40	3	1.20	1.90	Week 8
7	Breadboard	3.90	2	7.80	8.00	Week 8
8	Wiring bundle	5	2	10	7.72	Week 8
9	I2C 1602 Serial LCD for Arduino & RPI	7.90	1	7.90	9.90	Week 8
10	Resistor bundle	7.70	1	7.70	7.93	Week 8
11	Delivery fee (online purchase)				36.72	
12	OPC charges (collection in UTM)				10.00	
13	OLED LCD SSD1306	15.00	1	15.00	15.00	Week 12
			Total	179.66	197.80	

5. Product Prototyping

Prototypes of the overall product are divided into two parts which are the prototype of the reverse vending machine and designing the mobile application. For the prototype of reverse vending machine vending machine, the programming of coding is done for the features of weighing system, conversion of weight value of recycle item into money value and generate QR code that store the credit money from recycling. The mobile application design and coding are implemented with the functionality to store the accumulated credits and receiving credits from the reverse vending machine. The mobile application is also designed to be equipped with database connection in order to store user's account data. *Thunkable* is used as a platform for building and designing the mobile application while the *Google Firebase* is the database platform used for storing the user account information and data.

Discussion on Developed Product

Obstacle of developing the hardware

The initial plan is to develop a hardware that has multiple weighing sensors corresponding to the input type of material waste. However, due to the wiring of the weighing sensors exhibiting over-sensitivity, the calibration of the sensor is deemed impossible.

```
22:07:40.884 -> HX711 reading: 3542268   | average:   -41472.5
22:07:42.781 -> HX711 reading: 3542556   | average:   -41413.8
22:07:44.683 -> HX711 reading: 3542283   | average:   -41581.5
22:07:46.592 -> HX711 reading: 3540715   | average:   -43471.5
22:07:48.506 -> HX711 reading: 3539824   | average:   -44519.0
22:07:50.429 -> HX711 reading: 3538916   | average:   -45415.0
22:07:52.331 -> HX711 reading: 3537358   | average:   -46747.0
22:07:54.234 -> HX711 reading: 3539312   | average:   -45303.5
22:07:56.141 -> HX711 reading: 3539048   | average:   -43565.5
22:07:58.040 -> HX711 reading: 3541246   | average:   -42731.8
22:07:59.949 -> HX711 reading: 3540467   | average:   -47733.5
22:08:01.857 -> HX711 reading: 3542932   | average:   -412890.2
22:08:03.764 -> HX711 reading: 8382061   | average:   4798198.0
22:08:05.668 -> HX711 reading: 8381820   | average:   4798115.5
22:08:07.572 -> HX711 reading: 8382013   | average:   2157282.0
22:08:09.482 -> HX711 reading: 3569883   | average:   -13722.2
22:08:11.391 -> HX711 reading: 3577712   | average:   -4626.3
22:08:13.293 -> HX711 reading: 3580252   | average:   -3666.3
22:08:15.196 -> HX711 reading: 3579690   | average:   -4728.5
22:08:17.095 -> HX711 reading: 3578579   | average:   -5850.5
22:08:19.004 -> HX711 reading: 3577561   | average:   -6133.0
22:08:20.915 -> HX711 reading: 3588718   | average:   1045.0
22:08:22.826 -> HX711 reading: 3576651   | average:   -9125.5
22:08:24.733 -> HX711 reading: 3580602   | average:   -6619.8
22:08:26.637 -> HX711 reading: 3574434   | average:   -11404.5
22:08:28.540 -> HX711 reading: 3571489   | average:   -13020.2
```

Figure 3.1(left) Purchased weighing sensor (right) Output monitor in Arduino IDE

Figure 3.1 (left) 50kg load cell gauge as the weighing sensor with pre-installed wire (right) output of sensor without weight before calibration. The calibration process requires an added weight on the gauge and estimation will be conducted to convert the output to a unit of grams. When the weight is added, it was observed there were instability of the output's value. Touch the wires of the load cell was attempted, (time of touch highlighted in yellow at right figure) and the value increases drastically. After that, the values do not stabilize into the range of values before the yellow highlighted part. This was reflected as when a 250g weight was placed on the sensor, the displayed weight will be different when the weight is placed at different trials.

Discussion on simulation

The programmed script is based on the Python language; and by importing the Argparse module, users can type inputs in the terminal to simulate the actual scenario of using this system. The general command used for the script in Windows command prompt is as follows:

python <script_path> -- weight 200 --material aluminium

or

python <script_path> -w 200 -m aluminium

Since the shortcut -w to represent the --weight input was included, both flags can be used to declare the weight of the waste as 200g. Besides that, the type of waste material is declared using the flag --material or -m. The useful function of using the Argparse module is that user can access the help guide of using the script developed the the developer by typing *python <script_path> -h*

Based on previous study, since the price rate of the recyclable materials are in terms of kilogram, the script contains the necessary steps to convert the input weight into kilograms and multiply with the declared price rate. The output credit was ensured to be in two decimal places. Since the QR code can only contain information in string format, conversion needs to be done to change the credit amount to string format. Finally, the script will automatically display the QR code on the screen for the user to scan it.

Developed App

The app was developed by using a free online website called *Thunkable*, and the database used to store user information is the Google Firebase. The app was successfully developed such that users can sign up and authentication is done via email, and users can scan the QR code and accumulate the credits. Furthermore, the app has a page which lists the shops that can be accessed to claim the vouchers.

A personal QR code of the user in the profile page of the app have been incorporated. This is to be used as an input for the hardware to identify the user so that the hardware can develop a personalized QR code for that user only. The countermeasure was planned out to ensure that the users will not be able to abuse the system by giving other users to scan the same QR code.

Figure 4.1: Login Page

Figure 4.2: Sign Up Page

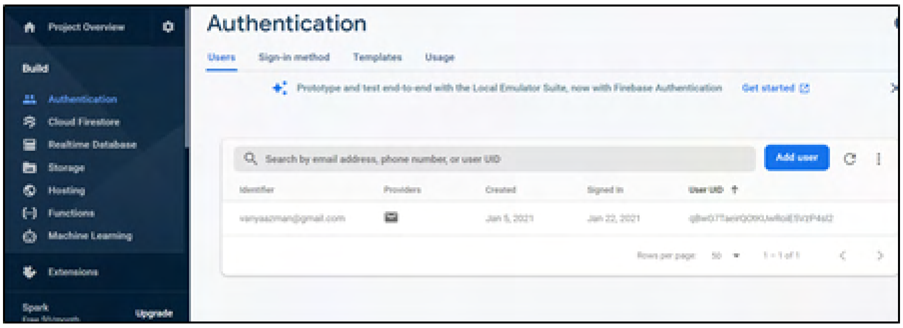


Figure 4.3: Authentication database

Figure 4.1 shows the Login page where users can choose to Sign Up, Sign In or Reset Password. To sign in, users need to input username, email and password. Figure 4.2 shows the Sign-Up page where first time users can enter their email and password to Sign Up. The database used for the application is Google Firebase. Figure 4.3 shows the authentication database which will store the first-time user's data when they Sign Up.

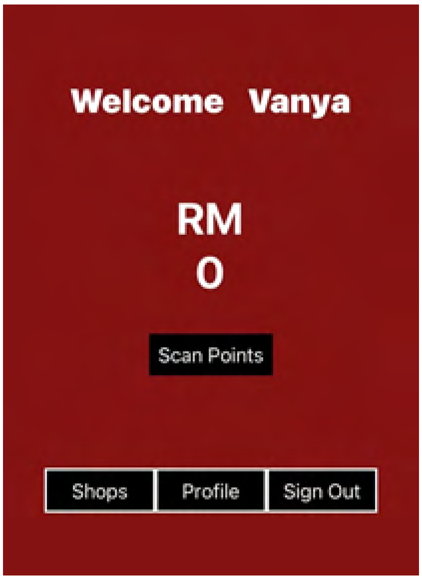


Figure 4.4: Home Page

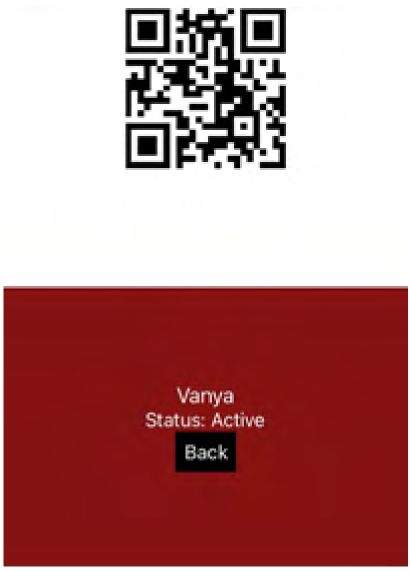


Figure 4.5: Profile Page

Figure 4.4 shows the Home Page where users can view their e-wallet balance when signed in. Users can also navigate to Shops, Profile and Sign Out. However, Figure 4.5 shows the Profile Page where users can scan their personal QR code to the machine for the machine to identify the user. For this page, a custom QR code for each user that has signed up was generated. The details in the generated QR code consists of the user's information when they signed up for this application.

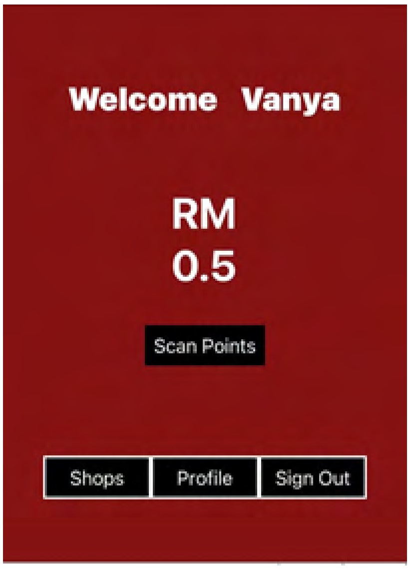


Figure 4.6: Home Page

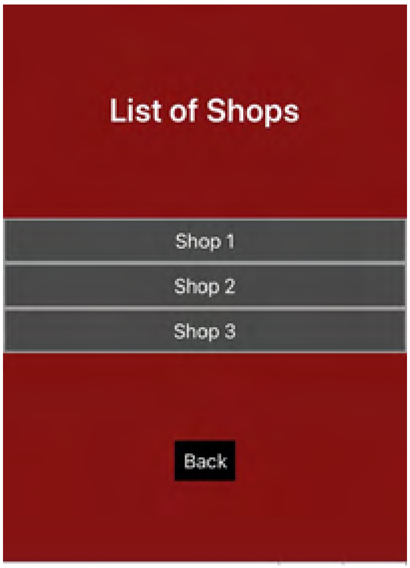


Figure 4.7: Shops Page

Figure 4.8: E-wallet balance database

At the Home Page, users can press the Scan Points button. When this button is pressed, the application is navigated to the user's phone camera. Then, users can scan the QR code from the machine to receive the reward in e-wallet. This process is shown in Figure 4.6. Meanwhile, Figure 4.7 shows the Shops page. When the Shops button is pressed from the Home Page, users can see the list of shops available to redeem rewards. Figure 4.8 shows the database to store the user's e-wallet balance when they scan QR code from the machine to receive reward.

Conclusion

In conclusion, from this team's data collection, it is proven that this project is able to encourage the students to recycle and keep the areas of UTM clean from recyclable waste while also training them to do self-recycle whenever they can outside the campus. Unfortunately, the hardware prototype was not able to be developed due to the faulty components. However, a software simulation that resembles the hardware machine and an application as the user interface was successfully developed. Both the software simulation and application shows the process of trading the recycled products and obtaining the rewards in return. Some of the improvements that can be made to this project is by adding Machine Vision to identify material type to replace manual material selection. This also ensures cheat-free scenarios such as putting in recyclable materials that are filled with liquid to increase the weight, hence getting more rewards. It would also be an improvement to have a personalized QR code from the machine to ensure rewards cannot be redeemed by anyone else except the current user. This is done by enabling the machine to scan the QR code of the user from the app, and after the whole weighing and conversion process, the software will join the credit and user identity into a string and display in a QR code. Then, the app will split the strings. If the user identity does not match the user name, the QR code will be invalid. Lastly, it would be an honour if the Management of UTM could make a system to enable the redemption of rewards for all the shops in UTM.

Acknowledgement

First of all, the authors would like to thank the School of Electrical Engineering, University of Technology Malaysia for providing us an opportunity to carry out this project virtually despite the inconvenience caused by the pandemic. The authors would also like to thank the project's supervisor, Dr Omar bin Abdul Aziz for endless support and guidance throughout this study in making this project a success. Besides that, the authors would like to express gratitude to the shop owners for their cooperation for an interview in order to obtain the relevant information. Lastly, the authors would like to appreciate the panel of judges for accessing and providing valuable feedback throughout the project development.

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[5] The YouTube video (https://www.youtube.com/watch?v=i1yDQuRWSkU) is an EcoBin project from University of Texas at Dallas.

[6] The YouTube video (https://www.youtube.com/watch?v=tDEPBFv48UE) is about Malaysia and the Broken Global Recycling System

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[8] https://console.firebase.google.com/u/0/project/capstone-f02eb/overview

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[10] https://docs.google.com/presentation/d/131oHFPkCUkgCTUbWa8Km3HhDopfWrGF3DaLajx7ahH8/edit#slide=id.p

PROCEEDINGS OF ELECTRICAL ENGINEERING CAPSTONE SHOWCASE (EECS 2020)
SCHOOL OF ELECTRICAL ENGINEERING, UNIVERSITI TEKNOLOGI MALAYSIA
SESSION 2020/2021
JANUARY 2021

Smart Trash Can

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Abstract: Our project is about the sustainable system in the faculty. The institution wanted to reduce the amount of trash cans in UTM, the problem of dustbin overflow and unattended full trash can. We have designed the smart trash can with three different operations which are auto opening and closing the lid, full dustbin indicator and the GPS navigation system. The chosen operations were based on the respondents' and the institution's needs. We were using Arduino Uno, NodeMCU, Ultrasonic sensor, Servo Motor and GPS module for the hardware, and the Blynk apps and Arduino IDE for the software.

Keywords: Smart Trash Can; Blynk Apps; Sustainable; Arduino; Full trash indicator;

Introduction

Sustainability is one of the core values of UTM. UTM spends around RM60,000 per month to manage solid waste, where as much as 40% of solid waste consists of non-recyclable waste. Hence, there is an ongoing effort in UTM towards zero waste. For example, practicing reducing the amount of trash can in UTM and practicing a plastic-free culture with the aim of reducing domestic plastic waste by 2022. UTM also wanted students and staff to practice bringing their trash when they get home. UTM is also concerned about the issue of carbon emissions in the campus. For example, the Car Free Day initiative has been launched since 2018.

Since the early of the Capstone Project, we have proposed our project title which is Smart Trash Can. At first, we decided to make it function as an auto opening and closing lid, full trash indicator, and plastic storage. After the evaluation session, the panels reminded us that UTM wanted to reduce the amount of trash can in UTM. Hence, we have to think about what kind of functionality in order to relate with the system. So, we had been thinking, to improve our smart trash can design in term functionality and what was its effect of reducing trash can in UTM.

One is the overflow of rubbish in the trash can. This is due to the fact that the rubbish collector is unable to collect the rubbish all the time. Besides, when the trash can is full, some people will throw it on the lid and it gives a bad reputation of UTM and gives a bad view. We cannot change the system, but we shall improve the system by designing this kind of product which could help the rubbish collector to notify and send the location of the full trash can to avoid overflowing the overflow trash can.

Often times, there must be a person who is stubborn and doesn't want to follow the zero-waste program proposed by UTM. They shall throw their rubbish into the river, drains, on the side of the road and anywhere else. It pollutes the water and clogged drains. However, the person who obeyed the system and wanted to keep their trash until they got home, the trash that they kept will give bad smell and they might forget to bring their trash since it left in the lecture room, office or somewhere. Most of the trash that the respondents throw is food waste rather than other types of waste.

So that's why we decided to choose these main functions which are auto opening and closing lid contactless, full trash indicator and GPS navigation system. The prototype was implemented with low cost materials. The ideas came from all of us and struggle to make it successfully work. Our first priority before determining the functionality is to analyze the data from Google form which was filled by 54 respondents. They stated their problem of the existing trash can. For example, the trash can is hard to open and manage. So, we decided to make an automatic opening and closing lid to fulfil the respondents' needs. The full trash indicator and GPS navigation system is the improvement of design after the comments by the panels. The developed prototype is shown in the further section.

In conclusion, data analysis is needed to decide what kind of product that we will design. Then, we improvise the idea and give a best shot on the prototype. We succeeded in making the prototype function well and worked successfully.

Content

1. Project or innovation objectives

The objectives of this project are:

- To fulfil the respondents' needs based on the data analysis.
- To implement a successfully smart trash can prototype
- To design a product which could mitigate the stated problem

2. Description and analysis of interview for the project, which can include findings in terms of pie chart, data extract and data clustering.

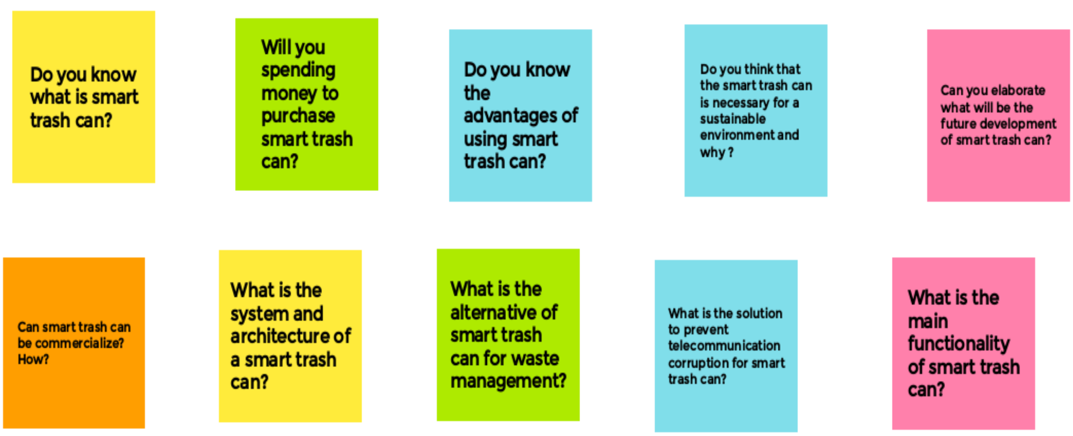
Description: The title for the survey is Smart Trash Can for Sustainable System. From the survey's results we extract the respondents' information and their thoughts towards Smart trash can and experience using traditional trash can.

Data clustering for questionnaire development:

Interview questions:

From Yassmin

Figure 1: M1 question suggestion for Google Form survey

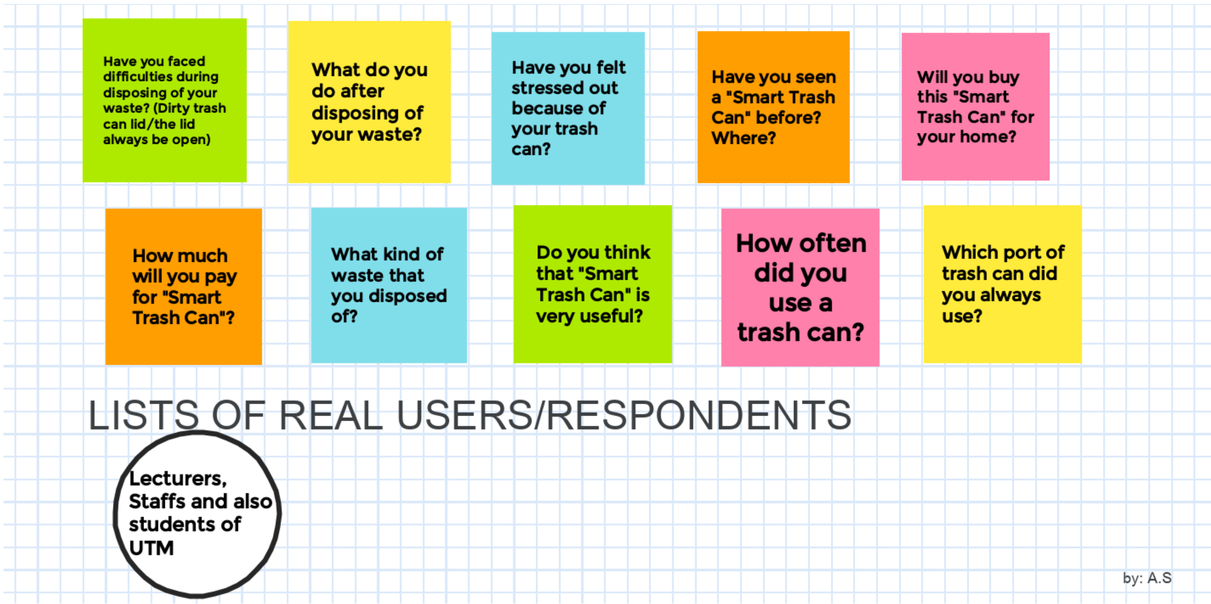


From Yap Kok Soon

Figure 2: M2 question suggestion for Google Form survey

From Amiroul Iqbal

Figure 3: M3 question suggestion for Google Form survey



From Aiman Syafiq

Figure 4: M4 question suggestion for Google Form survey

Findings: Respondent's personification

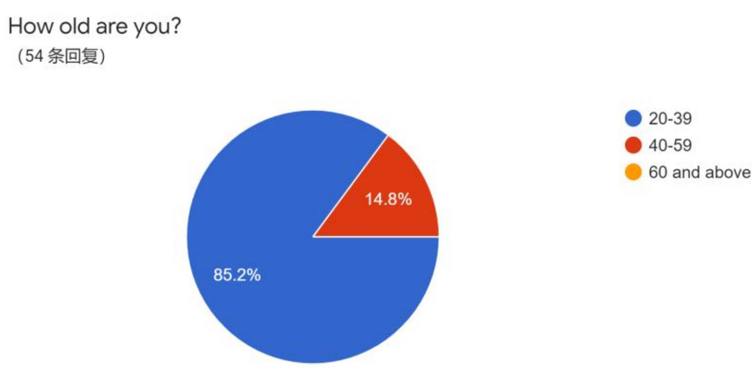


Figure 5: Ages of respondents

Gender
(54 条回复)

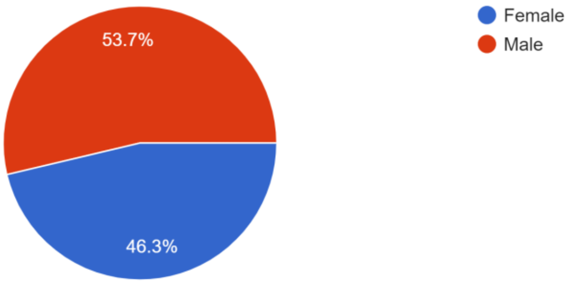


Figure 6: Gender of Respondents

What is your occupation?
(54 条回复)

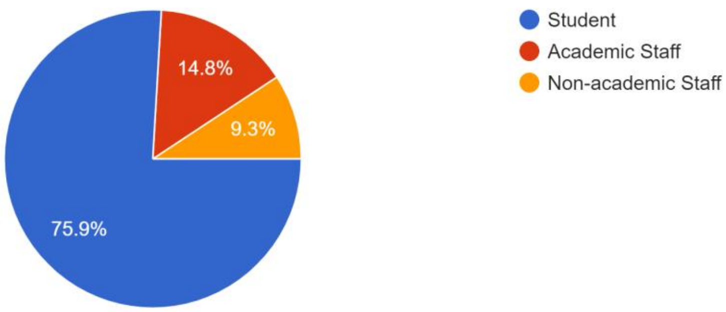


Figure 7: Occupation of Respondent

Findings: Respondents pain points

Which kind of trash can design that gave you difficulties?
(54 条回复)

Option 1 Option 2 Option 3 Option 4 Option 5

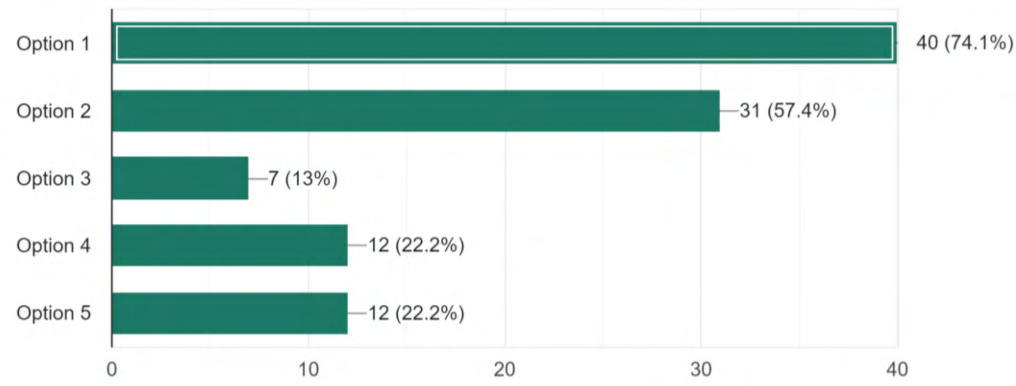


Figure 8: Design rating based on difficulties

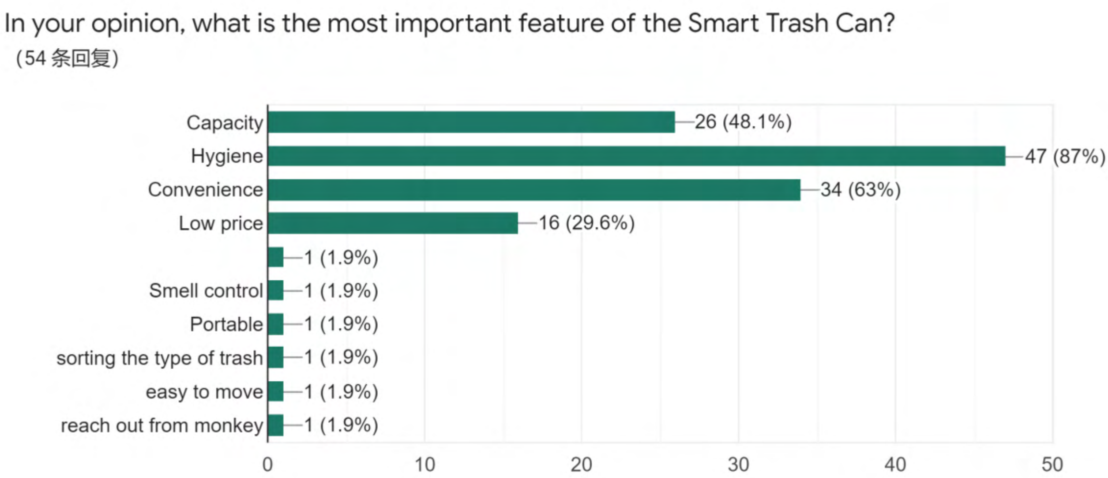


Figure 9: Most Important Feature Rating

Figure 10: Difficulties face when using traditional trash can

Findings: Respondents needs

Figure 11: Suggestion for Smart Trash Can functionality

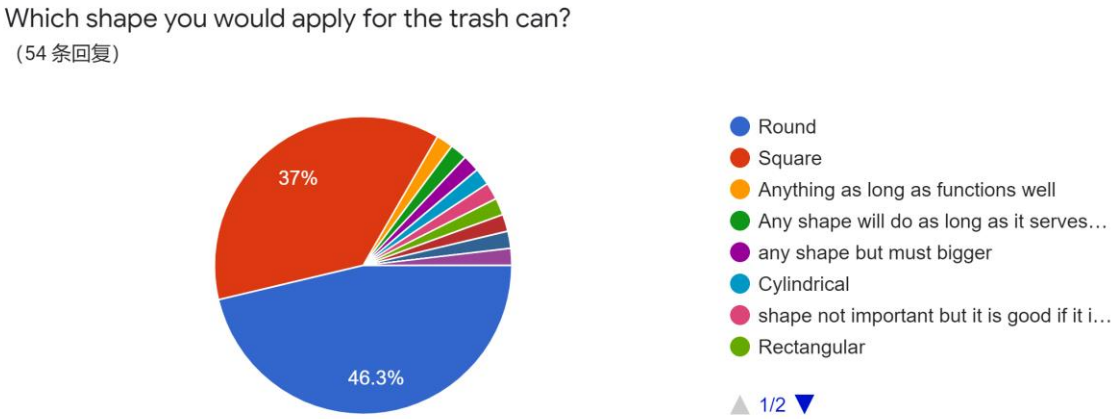


Figure 12: Most Preferable Shape for the Design

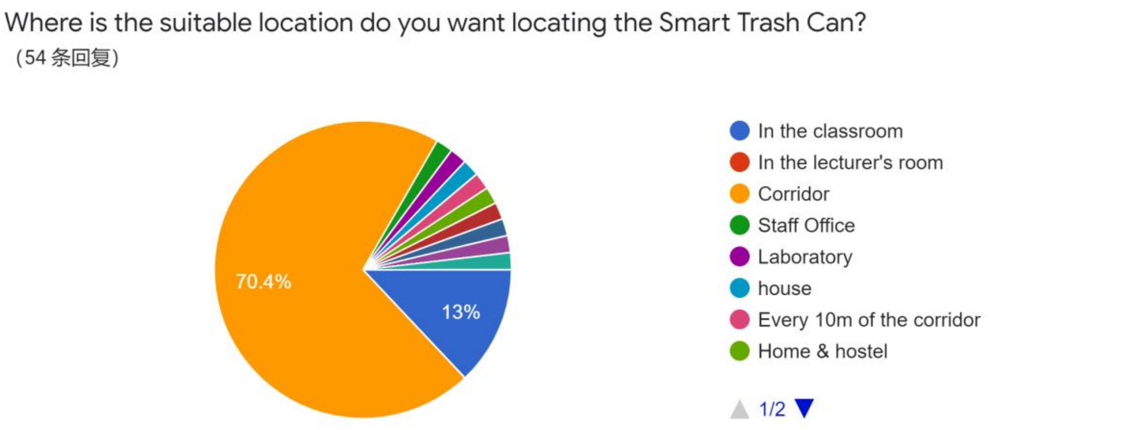


Figure 13: Most Preferable Location for Smart Trash Can

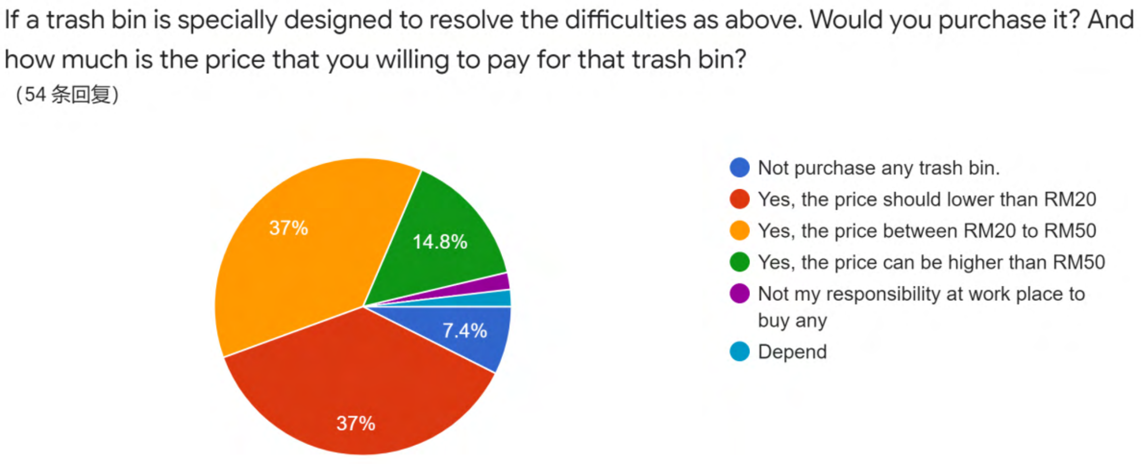


Figure 14: Pricing region

3. Design statement

Based on the data collection the design statement is developed according to respondents' pain points and needs.

The Smart Trash can having following functions:

- Auto-open lid
- GPS Tracker
- Send notification via Blynk to the rubbish collector when trash can is full
- Detect the status of trash can capacity
- Installable on any kind of trash can

During the presentation of the prototype, we received comment from the panel that UTM has decided to reduce trash can in campus. So, we added a GPS Tracker feature to navigate the location of trash can so that trash will not be missing. Furthermore, the notification sent to the rubbish collector on time can avoid the issue of ignored trash cans which are full of rubbish and unpleasant smell. This function also contributes to trash can reducing policy inside UTM area as previously the number of dustbins is essential to avoid the scenario of a full trash can which is always ignored by the rubbish collector. The capability to be installed on any kind of trash can also saves the cost to buy a new design of trash can. Overall, the new design of Smart Trash Can will improve the waste management inside UTM.

4. Methodology

List of components of Smart Trash Can:

a) Arduino Uno

b) NodeMCU

c) Ultrasonic Sensor

d) GPSi Module

e) Servo Motor

4.1 Design Auto Open Lid

Connecting servo motor

In order to open the lid, we have fixed a small plastic tube (like an empty refill of a ball-point pen) to the servo horn (a single ended horn) using instant glue. The lifting arm is parallel to ground under closed lid condition.

Connecting the Ultrasonic Sensor

We place the Ultrasonic Sensor fix to its position of the back of Smart Trash Can with the help of glue.

Wiring up the Components

The final step in the build process is to make the necessary connections using long connecting wires as per the circuit diagram and securing these wires so that they don't hang around. All the wires from both the components which is Ultrasonic Sensor and Servo MAC/fare connected to respective pins of Arduino.

Figure 15: Flow of the operation

```
void loop() {
  digitalWrite(trigPin1, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin1, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin1, LOW);
  duration1 = pulseIn(echoPin1, HIGH);
  distance1 = (duration1/2) / 29.1;
  safetyDistance = distance1;
  if (safetyDistance <= 10) {
    // goes from 0 degrees to 180 degrees // in steps of 1 degree
    myservo.write(90); // tell servo to go to position in variable 'pos'
    delay(15); // waits 15ms for the servo to reach the position
  }
  else { // goes from 180 degrees to 0 degrees
    myservo.write(0); // tell servo to go to position in variable 'pos'
    delay(15); // waits 15ms for the servo to reach the position }
    Serial.print("Distance: ");
    Serial.println(distance1);
  }
}
```

Figure 16: Arduino IDE coding for Auto Open Lid Feature.

4.2 Design Level Indicator Feature

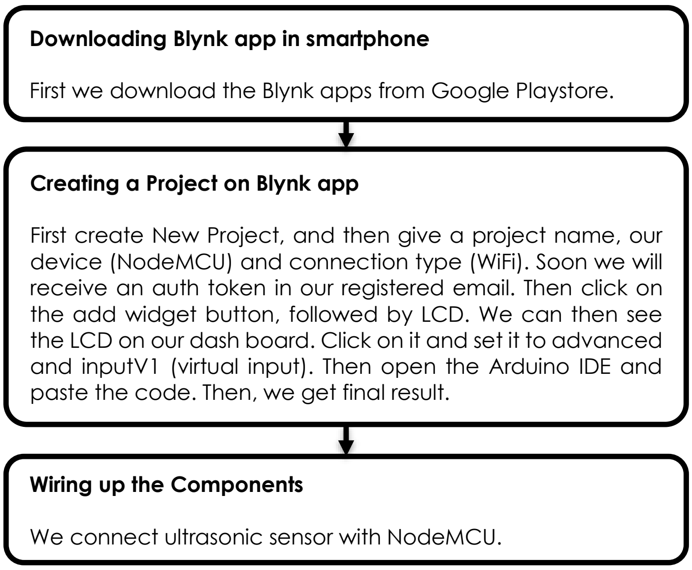


Figure 17: The flow of level indicator

4.3 GPS Tracker Feature

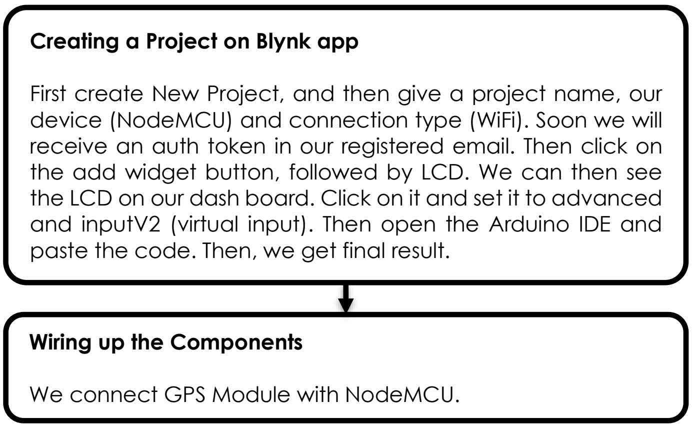


Figure 18: The flow of level indicator

```
    if (distance2 >= 14){
      Serial.print(distance2);
      Serial.println("Cm");
      lcd.print(7, 1, "EMPTY");
    }
    else if ( distance2 >= 4 & distance2 < 14 ){
      Serial.print(distance2);
      Serial.println("Cm");
      lcd.print(7, 1, "HALF FULL");
    }
    else {
      Serial.print(distance2);
      Serial.println("Cm");
      lcd.print(7, 1, "FULL");
    }


    Blynk.run();

    delay(2500);

  }
```

```
void gpsbin()
{
    while (ss.available() > 0)
    {
      // sketch displays information every time a new sentence is correctly encoded.
      if (gps.encode(ss.read()))
        displayInfo();
  }
  Blynk.run();
  timer.run();
}

void level()
{
  lcd.clear();
  lcd.print(0, 0, "The Bin Is..."); // use: (position X: 0-15, position Y: 0-1, "Message you want to print")

  digitalWrite(TRIGGERPIN2, LOW);
  delayMicroseconds(3);

  digitalWrite(TRIGGERPIN2, HIGH);
  delayMicroseconds(12);

  digitalWrite(TRIGGERPIN2, LOW);
  duration2 = pulseIn(ECHOPIN2, HIGH);
  distance2 = (duration2/2) / 29.1;
```

```
void displayInfo()
{
  if (gps.location.isValid() )
  {
    float latitude = (gps.location.lat());     //Storing the Lat. and Lon.
    float longitude = (gps.location.lng());

    Serial.print("LAT:  ");
    Serial.println(latitude, 6);  // float to x decimal places
    Serial.print("LONG: ");
    Serial.println(longitude, 6);
    Blynk.virtualWrite(V1, String(latitude, 6));
    Blynk.virtualWrite(V2, String(longitude, 6));
    myMap.location(move_index, latitude, longitude, "GPS_Location");
    spd = gps.speed.kmph();               //get speed
       Blynk.virtualWrite(V3, spd);

       sats = gps.satellites.value();    //get number of satellites
       Blynk.virtualWrite(V4, sats);

       bearing = TinyGPSPlus::cardinal(gps.course.value()); // get the direction
       Blynk.virtualWrite(V5, bearing);
  }

 Serial.println();
}
```

Figure 19: Coding for Level Indicator and GPS Tracker Features

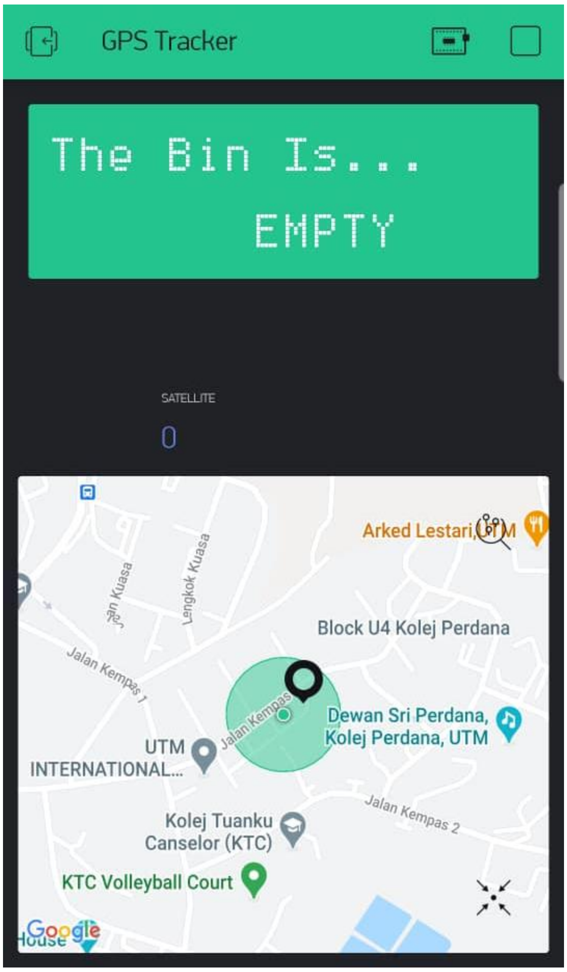


Figure 20: Blynk apps

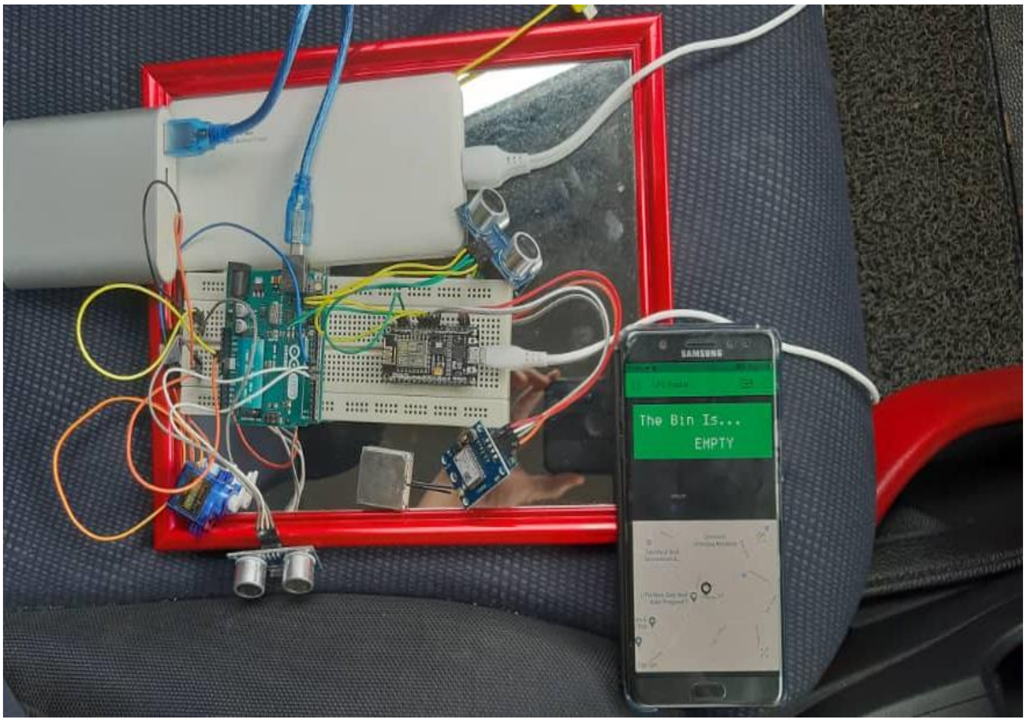


Figure 21: Testing and troubleshooting our Smart Trash Can

5. Product development

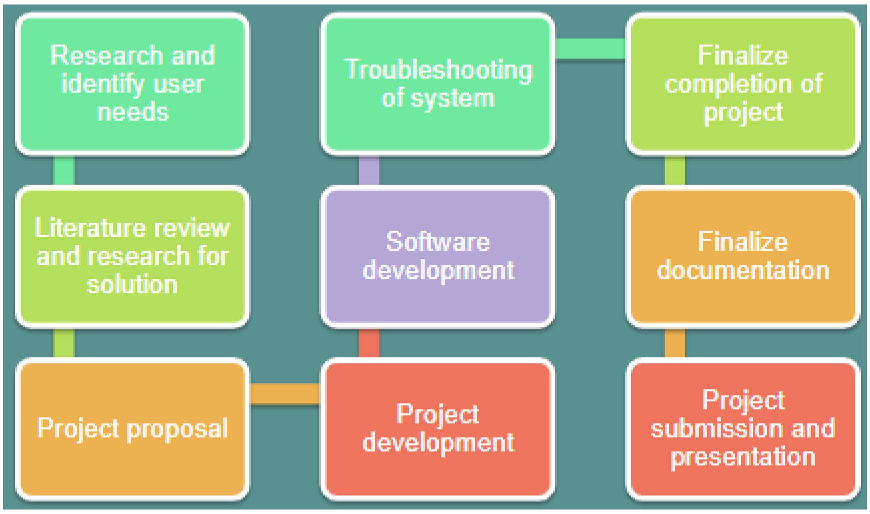


Figure 22: Flow chart Product Development

On Week 1, we all brainstormed to get the idea for developing a project that related to sustainability. Then, we did the research and identify user needs by distributing the Google form to students, academic staff and non-academic staff for School of Electrical Engineering. On Week 2, we proceeded to do literature review and did more research for a solution. From Week 3 to Week 4, we proceed to design the prototype by using Sketchup software. On Week 5, we proceed to present our conceptual prototype to the panels. The panels give more suggestions to improve our prototype project. After the presentation we all brainstorm the idea that came from panels and try to improve our prototype project. On Week 6, we proceed to draft the Gantt chart so that we have the schedule to complete our prototype project. We listed down the components for the project in Bill of Material. On Week 7 to Week 12, we all developed the project and troubleshoot any problem until we finalize the completion of the project and finalize the documentation. On Week 13, we presented our project to panels which are from lecturers and industrial panels. On Week 14, we all need to submit our final report and individual report.

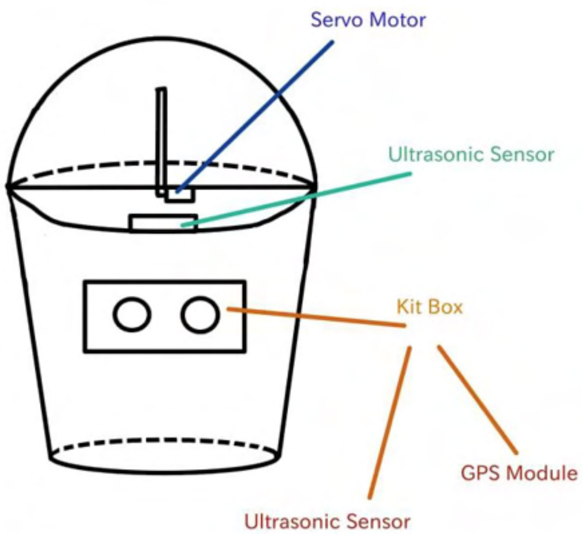


Figure 23: Prototype of Smart Trash Can

5.1 Gantt Chart

No	Tasks	Start Week	End Week	Capstone Week 5	6	7	8	9	10	11	12	13	14
1	Improvement of project idea	5	7	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐
2	Survey of equipments	6	7	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐
3	Purchase of equipments	8	9	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐
4	Hardware Progress	9	13	☐	☐	☐	☐	☑	☑	☑	☑	☑	☐
5	Software/App	9	13	☐	☐	☐	☐	☑	☑	☑	☑	☑	☐
6	Prototype implementation	9	13	☐	☐	☐	☐	☑	☑	☑	☑	☑	☐
7	Prototype testing	9	13	☐	☐	☐	☐	☑	☑	☑	☑	☑	☐
8	Prototype improvising	11	13	☐	☐	☐	☐	☐	☐	☑	☑	☑	☐

Figure 24: Gantt Chart

On Week 5 to Week 7, we tried to improve our project idea which came from our panels. From Week 6 to 7 we had conducted a survey for equipment which we bought on Week 9 the Arduino Uno cable USB, two ultrasonic sensors, WiFi Module and Servo Motor. From Week 9 to Week 13, we do hardware and software progress, and implementation, testing and improvising our prototype.

5.2 Bill of Material

No	Component	Estimated Cost			Purchased Price (RM)
		Unit Price (RM)	Qty.	Subtotal (RM)	
1	Cable Arduino Uno	3.00	1	3.00	2.65
2	HC-SR04 Ultrasonic Sensor	5.00	2	10.00	9.30
3	Servo motor	10.00	1	10.00	9.00
4	Push button	1.00	2	2.00	1.00
5	GPS module	22.00	1	22.00	20.90
6	ESP8266 Wi-Fi module	10.00	1	10.00	7.90
			Total	RM 57.00	RM 50.75

Figure 25: Bill of Material

We try to spend the cost of the project under the estimated budget. Based on the Bill of Material, we can conclude that the purchase price is under the estimated cost. We have purchased the component under the budget.

5.3 Feature and Operation

5.3.1 Auto Open Lid operation

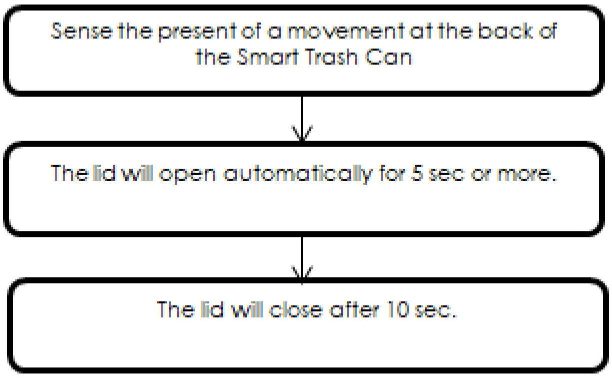


Figure 26: Auto Open Lid Operation

5.3.2 Level Indicator operation

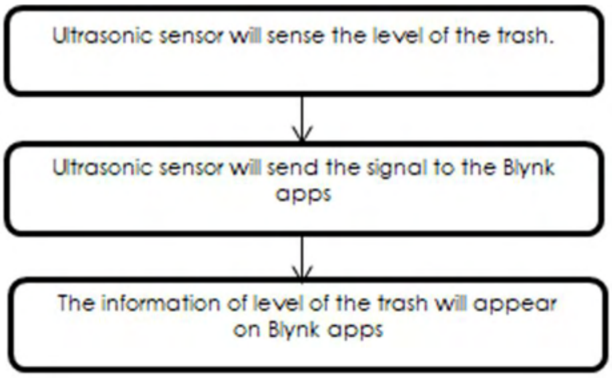


Figure 27: Level Indicator operation

5.3.3 GPS Tracker

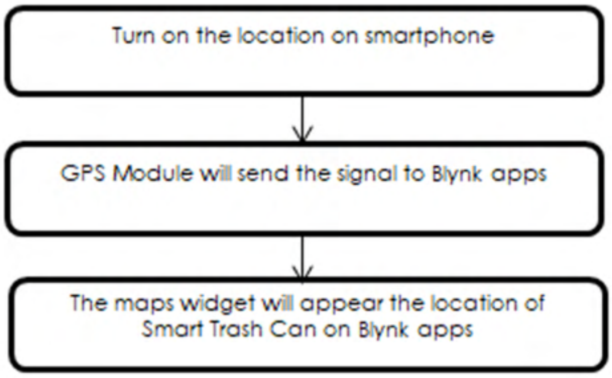


Figure 28: GPS Tracker

Figure 29: Smart Trash Can

6. Discussion on developed product

First and foremost, we are using only two different types of controllers, ArduiniUno and NodeMCU because there was error on auto open lid and level indicator operations when we combined all the coding for the three operations of the Smart Trash Can. So, we separated the operations into two parts, which is auto open lid operation connected to the ArduinoUno, meanwhile NodeMCU is connected with level indicator and GPS tracker operations.

From the panel's view, our Smart Trash Can product is a one direction sensor with problems in terms of practicality. As our box containing the hardware is huge and outside the trash can, it may disturb the practical work of the waste truck collector. Other than that, the major type of wastes in UTM is food wastes, which concerns the panels the most. When we talk about food wastes, the crucial factor is the number of days that the waste has been left in the trash can. So, our project can be improvised with the days counting and odor detection operations.

7. Conclusion

There are several problems with Smart Trash Can which is the capacity detection feature and its circuitry. This product is more convenient than a typical trash can. Smart Trash Can is very hygienic because of its auto open lid feature and also manageable with level indicator and GPS module for detecting the location of the trash can. For further improvement, we try to apply many features that can give more benefits to the user.

Acknowledgement

The authors would like to acknowledge Dr. Ahmad Shahidan bin Abdullah as he has given much guidance and knowledge in this field, which helps us a lot in completing this assignment.

Besides, we would like to express our thanks to our fellow friends that help and recommend the best solution or components that suitable to the project and lending their components for our project.

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Cat Repellent System: Get Off from SKE

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Abstract: This paper presents the development of a sustainable cat repellent system. Cat repellent systems may be useful to School of Electrical Engineering (SKE) as the rising number of cats are making a negative impact on the environment such as their litter, faeces and fur. This product used to repel cats from entering the SKE and hostel. The proposed cat repellent system is capable of emitting sound with frequencies that may repel cats. These frequencies can greatly repel animals such as cats by making them uncomfortable, hence leaving the area. However, the frequency used is harmless to the cats. This system detects the cats by using sensors which are an ultrasonic sensor and passive infrared (PIR) motion sensor with a detection range of 50 -100 cm. Once cats are detected, the system will generate a sound with a high output frequency that will repel the cat. The oscillation frequency of the cat repellent system is above 20 kHz. The system uses an SD card to store the sound file and communicate through an SD card module with Arduino. The system has been tested and it is functioning well. This will be useful for a sustainable SKE environment.

Keywords: Sustainable system; Repellent; Ultrasonic sound; SKE

Introduction

Cats are domestic cats, small, carnivorous mammals and most popular pets in the world. Cats are very clean animals because they will lick their fur themselves and use their tongue as hairbrushes that can clean and untangle their fur. However, if cats are not taken well, they would give a negative impact to the environment [1]. The common problems with cats are their faeces that are not properly managed. It may bring bad smell to the environment and more critically, there are chances of diseases spreading in the area. Especially in places like faculty where it is a formal and professional environment, cat faeces may bring a bad image and affect the surrounding people. Although there are cleaners who are responsible for cleaning the faculty, as more cats stay in the faculty, problems become more critical and it increases the workload of the cleaner.

There are many methods that can be used to repel cats, for example cat away spray [3], electric fence [2] and etc. The electric fence method may be harmful to cats since it gives an electric shock to the cat that passes through the area. Some systems use sharp light to repel the cats which is not suitable to use in the faculty because many students and lecturers will pass by the entrance. Most of the repellent systems in the market targeted customers such as gardeners where they do not want cats to come near by the garden and destroy their plants. However, this system is not suitable to be used in the faculty. Also, the prices for each system are slightly expensive and it is harmful to the cats.

Hence, considering the environment in Universiti Teknologi Malaysia (UTM) campus, a cat repellent system is proposed. The proposed system is equipped with a device that is capable to differentiate between humans and cats. It uses two ultrasonic sensors and a PIR motion sensor to detect cats and generate sound to repel the cats from entering an area. This method required less budget and the sound produced is not harmful to the cats. The system is suggested to be placed in the corridor and entrance of the staircase. The sound that generated from a speaker causes irritation to cats but not harmful to them. On the other hand, this system is useful for faculty members when eating in the cafe or if you do your work the cats never disturbed you.

Cat repellent system is not a system to diminish the cats but to avoid cats coming nearby certain places like the faculty. Hence, with the system a hygienic environment is promising and everyone can enjoy studying and working in healthy condition. In addition, the workload of the cleaner may be reduced. More improvement may be made to improve the system further for example by improving the range of detection, material for casing protection and cloud-based system.

Project Objectives

1. To identify suitable types of sensor to detect and sound to repel cats but not harmful to them.
2. To integrate hardware and software for complete cat repellent system development.
3. To test the developed cat repellent system for its functionality.

Description and Analysis of Interview

The interview for the project is done through two methods. The first method is using data collected from the survey through Google Forms. Google Forms is a free web-based application which is commonly used to conduct surveys for data collection purposes as it is easy to distribute through social media. This form consists of twelve questions about others opinions' on cats and the proposed solution to the problem of cats. Second method is done through face-to-face interviews with cleaners and students in Kolej 10, UTM. The purpose of the interview session is to collect data and have a better understanding from the users on the problems related to sustainability so that the proposed project can be developed according to the user's needs. Some of the examples of problems related to sustainability that can be developed in the faculty are the air quality management, cat waste management and food waste management systems. This project focuses more on dealing with cat waste management through prototyping methods.

For the analysis of survey through Google forms, the scope of the survey has been specified to the problems about cats and how to manage their waste. From the pie charts in Figure 1 to Figure 4, the extracted information consists of the number of respondents, how often seeing cats in the faculty, percentage of respondents who like cats and percentage of people agreed cats may cause cleanliness problems. While the extracted information from the respondents' opinions are problems about cats, methods to avoid cats from entering an area, opinions on using cat repellent sound and suggestion on prototype design. Besides the questionnaire, a video link is included in the Google form which is taken to give overview and better understanding to the problem before respondents answer the survey. The title of the chosen video is '*Top 10 Pros and Cons of Having Cats in a Home*'.

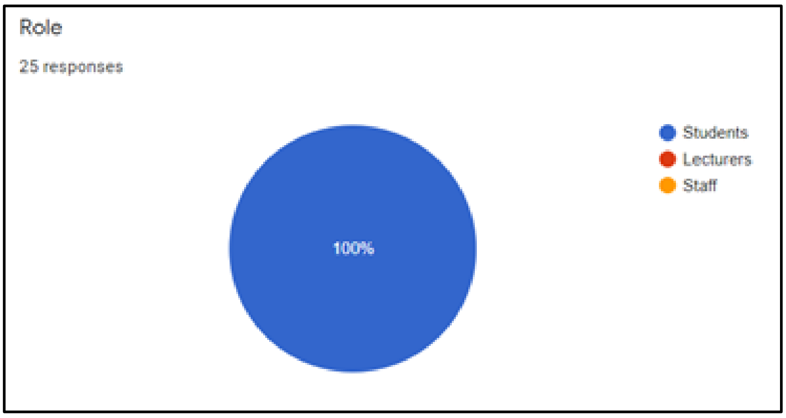

Figure 1: Number of respondents of survey

25 students have answered the survey as shown in Figure 1. Most of them are from SKE while others are from other schools. From Figure 2, 84% of the respondents always see cats in the faculty while the others only see cats in faculty sometimes. This shows that the numbers of cats in UTM are high and there is no specific place for shelter. 80% of the respondents like cats as shown in Figure 3. The developed questionnaire is useful to get an insight of the problem with cats, and even cat lovers are aware of the problem caused to the environment.

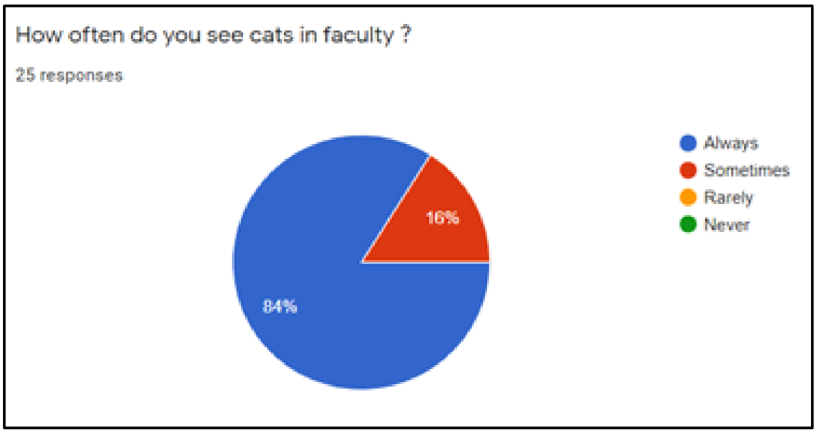

Figure 2: Percentage of respondents often see cats in the faculty

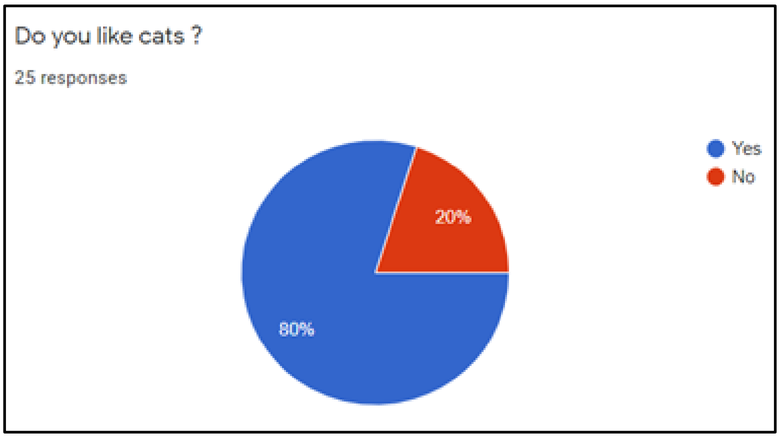

Figure 3: Percentage of respondents like cats

From Figure 4, only 40% agreed that it is good to have cats in faculty and 68% agreed that cats caused cleanliness problems in the faculty. This shows that the majority of the people think that it is not a good idea to have cats in the faculty as it is a place for education while cats can cause cleanliness problems such as bad smells from cats litter and this will affect the students for effective learning. After further study and analysis from research, using a sound frequency to repel cats is an effective and efficient way as it does not harmful to cats as the sound is only heard by cats for a few seconds.

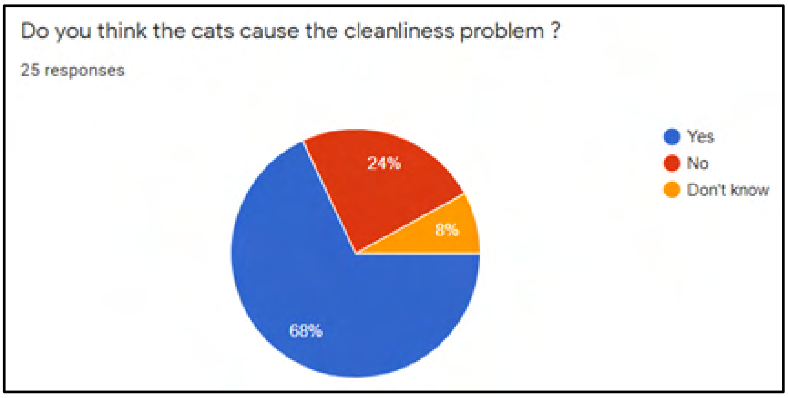

Figure 4: Percentage of respondents agreed cats cause cleanliness problems

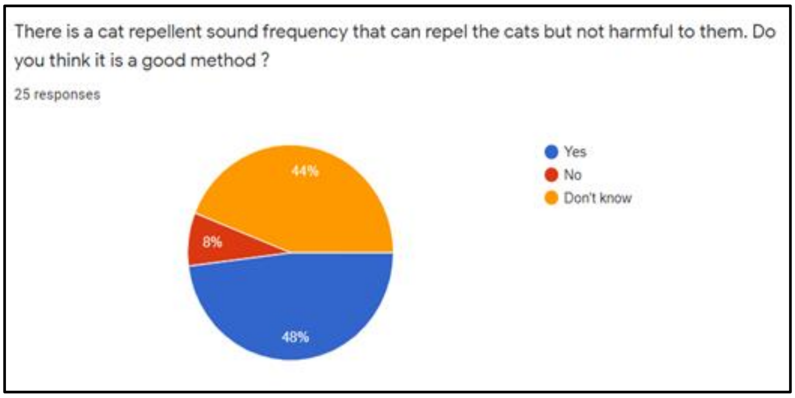

Figure 5: Percentage of respondents agreed using sound frequency is a good method

Next, users are asked for opinions on using sound frequency to repel the cats. The sound used is a high frequency which can bring irritation to the cats so that they will not enter the remark area. Figure 5 shows about 50% of the respondents agreed of using sound frequency to repel cats from entering the targeted area, as long as it does not bring harm to the cat. Other than that, the opinions from the respondents are also taken into consideration for future development of the prototype. The suggestions to the product are low budget, easy for installation and rechargeable. The price is compared with the existing cat repellent product in the market. The student suggested that by adding a device featuring fragrance to the prototype as the sound produced from the spray and strong smell might be able to improve the system with greater repellent effect. This has greatly increased the concern especially from the users who are allergic to the cats. Besides that, some users suggested to use red colour bottles or smells that can drive out the cats. Some suggested to stop feeding the cats in the faculty or crowded area.

Aside from the analysis through the survey, the analysis is also done through face-to-face interview sessions. The interviewees consist of one student and two cleaners. The questions asked are the same as the surveys and the session is recorded for further analysis. Cleaners often deal with the cats and they understand the problem clearly. Hence, it is best to have suggestions from them. The cleaners agreed that the device will help them a lot by reducing their workload of cleaning.

Design Statement

This project aims to reduce the workload of cleaners and provide a clean and comfortable environment to the students by preventing cats from entering the faculty using the proposed cat repellent system. This system is equipped with a PIR motion sensor and ultrasonic sensor to detect motion of cats while a speaker is used to produce sound to repel the cats. These components are integrated with Arduino Uno microcontroller along with Arduino IDE software and the prototype is suitable to be placed in any entrance of faculty.

Methodology

The technology required for the project consists of hardware and software selected based on the function of the system to detect the cats and avoid them from entering an area. The details of each technology and materials used will be further discussed on its functionalities. Each of the chosen materials purchase is according to the current availability in the market. Comparison is made between various types of materials to fulfil the project requirements and objectives. The comparison for the price is also made between the same function of components to get the lowest possible price so that the final product can compete with existing products in the market with low cost.

STEEP Analysis

During the early stage of project development, Sociological, Technological, Economical, Environmental and Political (STEEP) analysis is discussed and analysed before the design process. Design model is built to show the overview of the working principle of the system, and the STEEP analysis is as described in Table 1. STEEP analysis is used in the project planning to get a detailed overview on the external factors that determine the trends. STEEP analysis can also help team members to get a better understanding of how each factor affects the planning process.

Table 1: Description of STEEP analysis

Areas	Descriptions
Social/Cultural	• Health of students and lecturers • Build a professional environment for education
Technological	• Internet of Things • Smart automation system • More connectivity/functionality
Economical	• Reduce cleaning frequency • Sustainable system • Low cost/ budget
Environmental	• Cleanliness problem • Conformatable
Political	• Safety issue • Environment protection law

After analysing the data collected through survey and interview sessions, the conceptual prototype is designed by taking into consideration users' needs and suggestions on prototype design. The conceptual prototype is important to get the overview of the whole product on how the system works and the components needed to make it function properly as suggested by the users. It is also designed based on STEEP analysis. STEEP stands for Social, Technological, Economical, Environmental and Political.

Figure 6 shows the sketch of the prototype which consists of sensors, speaker, power supply and microcontroller. There will be two sensors mounted at different heights level to detect and differentiate between humans and cats. Upper sensor will be used to detect humans and placed at a height higher than an average height of a cat while the lower sensor is used to detect cats. The speaker is triggered when only the lower sensor detected an object and PIR motion sensor detected a motion. Figure 7 shows the target building and place which is suitable for the prototype placement to avoid cats from entering. The prototype will be placed at the entrance of a path or stairs so that cats cannot enter the restricted area which is used for important and personal matters such as living places, study area or cafe.

Conceptual Prototype Development

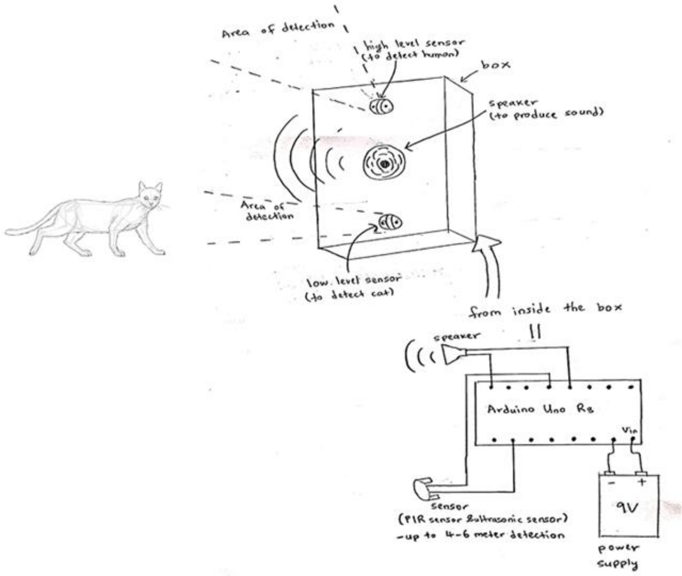

Figure 6: Sketch of conceptual prototype

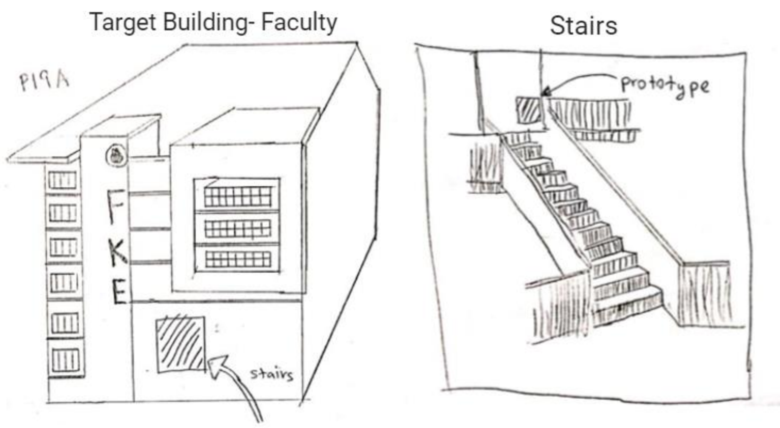

Figure 7: Target building for prototype placement

List of Components and Software Used

- Arduino IDE Software
- Arduino Uno R3
- PIR sensor (HC-SR501)
- Ultrasonic Distance Sensor (HC-SR04)
- Speaker (LM386)
- Micro SD Card
- SD Card Module (Adapter)
- Power Supply (Powerbank)
- Jumper Wire and Breadboard

- **Arduino IDE**

An Integrated Development Environment (IDE) is needed to program the microcontroller. This IDE contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus [5]. There are two types of IDE that are specifically for the Arduino environment. The first one is offline which the software has to be installed while the second type mode is online, in which the IDE is using the latest and updated functions library. This IDE allows the board programming to be achieved practically. The IDE does support multiple boards in which practically almost the same for every board such as Arduino Uno, Arduino Mega, Arduino Nano and NodeMCU [5]. The library that can be used by the 42 open-source helps the instruction to be done mediocre. Though, that creates a problem where not every library out there meets the need for the use. The alteration has been done to suit the requirement better.

- **Arduino Uno R3**

Arduino is a platform where it is allowing an individual to develop something useful and beneficial to ease their works. It is a combination of hardware and software. Even though users did not have much knowledge about programming and electronics, it will not be a problem [6]. In short, it is the best tool for prototyping products. Many projects that involve IoT have selected and utilise the usage of Arduino Uno as one of the best choices due to the low price compared to other microcontrollers. People all around the world are doing a project and variety of application from complex to a simple one. Figure 8 shows represents the Arduino Uno R3 board as the microcontroller.

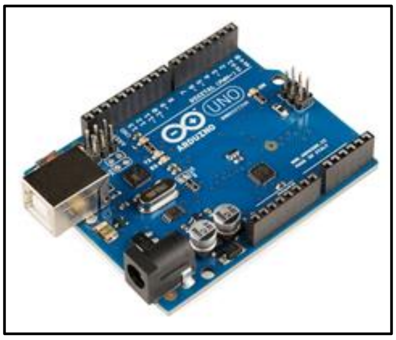

Figure 8: Arduino Uno R3 board physical view

The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. Programs can be loaded onto it from the easy-to-use Arduino computer program [6]. The Arduino has an extensive support community, which makes it very easy to get started working with embedded electronics. The R3 is the third, and latest, revision of the Arduino Uno. The Uno differs from all preceding boards as it does not use the FTDI USB-to-serial driver chip. Instead, it features an ATmega16U2 programmed as a USB-to-serial converter [6]. This auxiliary microcontroller has its own USB bootloader, which allows advanced users to reprogram it. Table 2 tabulates the details of Arduino Uno R3 board specifications.

Table 2: Arduino Uno R3 specification

Parameter	Description
CPU	ATmega328P
Input Voltage	7V – 12V
Digital pins	14
Analog pins	6
Flash Memory	32 KB
Clock Speed	16 MHz
DC Current for each I/O Pin	40 mA
DC Current on 3.3V Pin	50 mA
IDE	Arduino IDE
SRAM	2KB
PWM pins	3, 5, 6, 9, 11

- **PIR Sensor (HC-SR501)**

The PIR sensor stands for Passive Infrared sensor. It is a low cost and low power sensor which can detect the presence of humans or animals especially cats. This sensor has three output pins Vcc, Output and Ground. Since the output pin is 3.3V TTL logic, it can be used with any platforms like Arduino, Raspberry, PIC, ARM, and 8051 [7]. All objects with a temperature above Absolute Zero (0 Kelvin / -273.15 °C) emit heat energy in the form of infrared radiation including human bodies. A PIR sensor is specially designed to detect such levels of infrared radiation. It basically consists of two main parts: A Pyroelectric sensor and a special lens called Fresnel lens which focuses the infrared signals onto the pyroelectric sensor [7]. Figure 9 shows the PIR sensor used to detect motion through infrared. Table 3 shows the details of PIR sensor specification.

Figure 9: PIR sensor physical view

Table 3: PIR sensor specification

Parameter	Description
Working Voltage	4.8 V – 20 V
Power Consumption	65 mA
Logic Output	3.3 V
Delay time	0.3 s – 200 s, custom up to 10 min
Lock time	2.5 s (default)
Trigger	repeat : L = disable , H = enable
Sensing range	within 7 m
Operating Temperature	– 15 ~ +70 °C
Sensor Angle	<110 ° cone angle

- **Ultrasonic Distance Sensor (HC-SR04)**

HC-SR04 Ultrasonic sensor is a 4-pin module, whose pin names are Vcc, Trigger, Echo and Ground respectively. This sensor is a very popular sensor used in many applications where measuring distance or sensing objects are required. HC-SR04 distance sensor is commonly used with both microcontroller and microprocessor platforms like Arduino, ARM, PIC and Raspberry Pi [8]. The module has two eyes which forms the ultrasonic transmitter and receiver. The ultrasonic transmitter transmits an ultrasonic wave. The wave travels over the air and when it gets objected by any material, the wave will be reflected back toward the sensor. The reflected wave is observed by the ultrasonic receiver module. The time during which the Echo pin stays high is measured by the MCU/MPU as it gives the information about the time taken for the wave to return back to the sensor [8]. This sensor is used to detect cats whenever there is a motion within the set of range. Figure 10 shows the ultrasonic distance sensor used to detect motion of cats through echo. Table 4 shows the details of ultrasonic distance sensor specification.

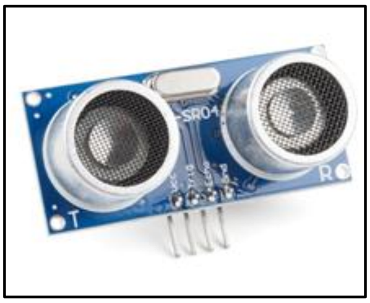

Figure 10: Ultrasonic distance sensor physical view

Table 4: Ultrasonic distance sensor specification

Parameter	**Description**
Operating Voltage	5 V
Operating Current	15 mA
Working Frequency	40 Hz
Max Range	4 m
Min Range	2 cm
Measuring Angle	15 degree
Trigger Input Signal	10 uS TTL pulse
Echo Output Signal	Input TTL level signal and the range in proportion
Parameter	Description
Operating Voltage	5 V
Operating Current	15 mA

- **Speaker (LM386)**

Mini speaker compatible with Arduino boards are used to produce a sound which can irritate the cats and repel them. When cats are detected by the sensors, the speaker will play the sound installed in the SD card as a normal buzzer cannot use this function. The speaker has two pins consisting of data pin and ground. Different sound frequencies can be played by modifying the program. The operating voltage for the speaker is between 3.3 V to 5 V and the type used is LM386. As cats are sensitive to the high frequency sound, so nothing to worry about the volume of the speakers as cats can hear four to five times farther than humans. Figure 11 shows a mini speaker used to produce sound to repel cats.

Figure 11: Mini speaker physical view

- **SD card and SD card holder**

Storing data is one of the most important parts of every project. There are several ways to store data according to the data type and size. SD and micro SD cards are one of the most practical ones among the storage devices, which are used in devices such as mobile phones and minicomputers [9]. The SD and micro SD card modules allow the user to communicate with the memory card and write or read the information on them. The module interfaces in the Serial Peripheral Interface (SPI) protocol [9]. To use these modules with Arduino, SD library is required. This library is installed on the Arduino application by default. In this system, SD card will be used to store the high frequency sound downloaded which is used to repel cats as the Arduino board is unable to store files. The operating voltage of the SD card module is 3.3 V to 6 V and the file is saved in a WAV file. Figure 12 shows the SD card and SD card module.

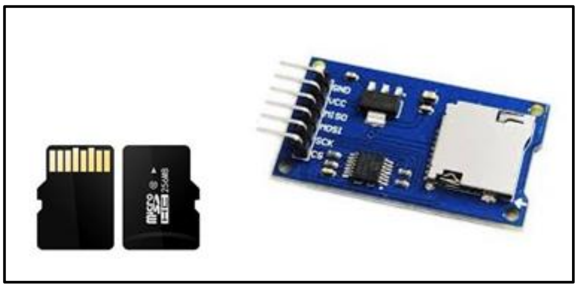

Figure 12: SD card and SD card module

Product Development

The proposed system development begins by choosing suitable components for the project. For a cat repellent system, two ultrasonic distance sensors and one PIR motion sensor are needed. The sensors are used to detect the cat and differentiate between the cats and the humans. Ultrasonic sensors are mainly used to detect if there is an object nearby while a PIR motion sensor is used to detect motion. Two types of sensors are used to improve the accuracy of detection. Beside the sensor, a speaker for playing the repellent sound that can repel the cats is also needed.

An SD card is used to store the sound repellent file because the Arduino is a microcontroller which is unable to store files in it. Hence, to communicate between SD card and Arduino, an SD card module is used. File needed to be converted into a #.wav file so that the Arduino can read the file and produce sound via the speaker.

Then, Arduino Uno is chosen as the microcontroller that controls the system of the project, while breadboard is used to connect all the components. The chosen components are connected into one circuit connection on the breadboard. Extra precaution is required to ensure all parts are properly and completely connected. Then, the Arduino code is developed. This process is needed because the Arduino itself will control the system as wanted by the developer. Basically, the coding is the core of the system.

After coding, the prototype was tested and the output is analysed. In this project, the speaker will produce a sound if only the bottom sensor of the ultrasonic sensor and PIR motion sensor detected a cat passes by. The speaker will not produce sound if both sensors are triggered simultaneously. In case of error, troubleshooting the error is needed either by modifying the coding or in the circuit connection. Once the intended output is achieved, the prototype will be evaluated for data collection. Figure 13 illustrates the summary of product development process.

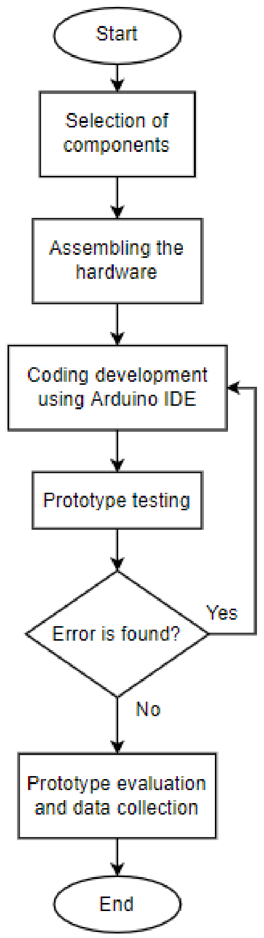

Figure 13: Summary of the product development

After development of the prototype is completed, the evaluation and data collection is done. The developed prototype is evaluated by testing it with the real cats. Functionality of the sensor is also one of the aspects needed when evaluating the system. Once the bottom sensor detected a cat and a motion, the speaker will produce repellent sound. The cat run away due to irritable but nor harmful sound from the speaker.

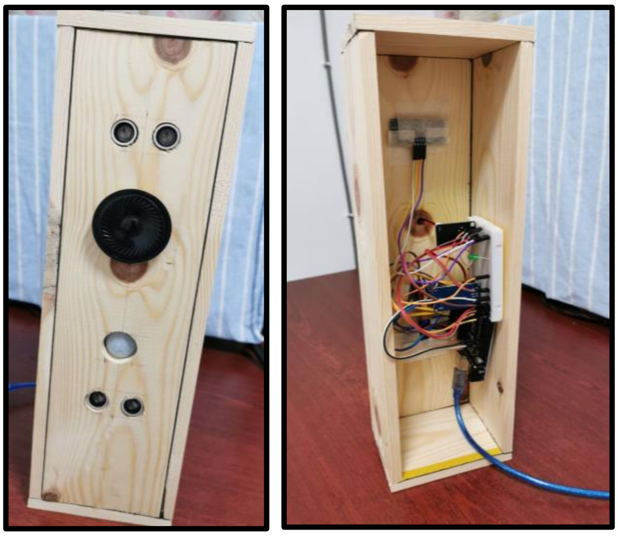

Figure 14: Front view and internal view of the final product

Results and Discussion on Developed Cat Repellent System

The prototype has been successfully developed and functioning well. The prototype was tested indoors due to the Movement Control Order in which the outdoor activity is restricted. Both sensors were tested by moving an object mimicking a cat in front of the system. For human detection, when a human pass by, the speaker was not trigger. While when an object mimicking a cat passes by, the speaker produces the ultrasonic sound, as the bottom sensor detected an object nearby. Table 5 shows the truth table of the system.

Table 5 : Truth table of the system

Ultrasonic sensor (high)	Ultrasonic sensor (low)	PIR motion sensor	Speaker
X	X	0	Not triggered
X	0	X	Not triggered
1	X	X	Not triggered
0	1	1	Triggered

Project flow

This project progress begins with brainstorming the idea on Cat Repellent System to gather some ideas on the project title. After that, the questionnaires are designed and face-to-face interview sessions is arranged for data collection about problems caused by the cat. After that, the proposed system is developed through software and hardware integration including selecting and assembling the electronic components, developing the coding for Arduino Uno R3, prototype testing and prototype evaluation and data collection. The overall project plan is summarized in a Gantt chart as shown in Figure 15 and the flowchart is shown in Figure 16.

No	Tasks	Start Week	End Week	Capstone Week										Remark upon Task Completion
				5	6	7	8	9	10	11	12	13	14	
1	Conceptual design evaluation	5	5	✓										
2	Planning on project development	6	6		✓									
3	Buying material(mid sem break)	6	6		✓									
4	Assembling material	7	7			✓								
5	Engineering Drawing	7	7			✓								
6	Hardware and software development	8	9				✓	✓						
7	Testing	10	10						✓					
8	Fine tune	11	11							✓				
9	Project presentation	13	13									✓		
10	Technical Report preparation and submission	13	14									✓	✓	
11														
12														

Figure 15: Gantt Chart of project workflow

The system starts its operation by detecting the cat by using ultrasonic and PIR motion sensors. There are two ultrasonic sensors purposedly placed at the top and bottom of the prototype to differentiate between a human or a cat. If the bottom sensor is triggered, it would sense as the cat passed by and the speaker would produce the ultrasonic sound. While if the top sensor or both sensors are detected, it would sense as the human passed by and no sound is produced. The prototype is functioning well as planned. Unfortunately, due to the Movement Control Order, the on-site testing cannot be performed. An object mimicking a cat is used in the indoor testing to confirm the functionality of the sensors and overall system.

After testing the prototype (refer Figure 17), a demonstration video is sent to potential users, and the feedback is gathered and analysed. Most of them commented that the prototype is a good product since it can repel the cat just by itself and not disturb the user. However, there are still improvements suggested by the users. One of them suggests that the protection of the device needs to be improved because the speaker originally placed outside the box. Next, users also commented that the prototype distance coverage needs to be improved. Besides that, the casing of the prototype can be changed into material that is waterproof. Moreover, for the microcontroller, users suggested that better performance can be achieved by using Raspberry Pie if compared to Arduino Uno R3.

For future works, the prototype can be further improved by considering the feedback stated. Besides, the developed system may be useful at most buildings in UTM in general, and the system output may be monitored by Cat lovers society or sustainable community for further action. In addition, Cat Park may be introduced and open for public such as the Taman Rusa in UTM.

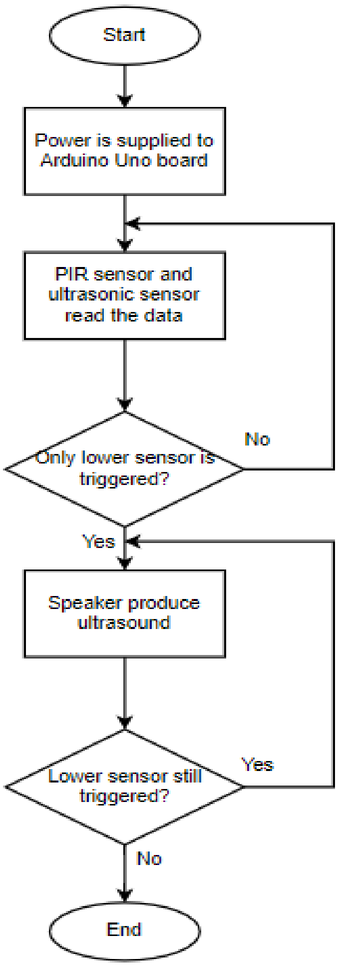

Figure 16: Flowchart of Cat Repellent System operation

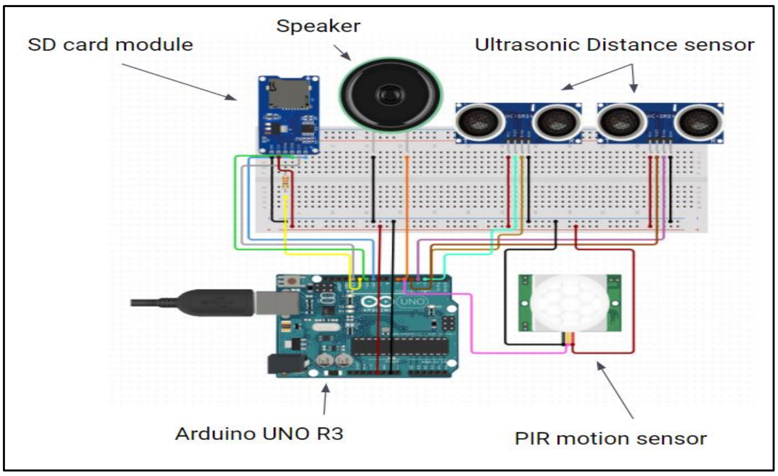

Figure 17: Prototype of Cat Repellent System operation

Conclusion

In conclusion, a Cat Repellent System has been successfully developed. PIR motion sensor and ultrasonic sonic sensor have been identified and integrated with Arduino UNO R3. The system is capable of detecting cats pass by and can differentiate between humans and cats. Besides, the system can produce sound to repel the cats. The developed prototype has been tested and it is functioning well as planned. The developed product can be further improved in terms of range of detection using different sensors or apply deep learning using Raspberry Pi. Moreover, the casing used may be protected by using suitable material to increase its lifespan.

Acknowledgement

Firstly, we wish to express deepest gratitude to our supervisor, Dr. Noor Asmawati binti Samsuri. Throughout the semester, her constant support and much time spent helped us complete this project. Without her guidance, it seems not possible to complete this project so smoothly. Also, we take this opportunity to express gratitude to all the School of Electrical Engineering staff, members and students that helped throughout the different stages of the project. Besides that, special thanks to the cleaner in SKE and hostel as the main respondents of the project. This project would not have been possible without their help and insight. None the less, thank you to our parents and family for supporting us when we run the meeting and they understand we are through the online class. They instilled the love of giving attention to what we do. The journey of completing this capstone project has been a great learning experience and we have learnt so much from it.

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PROCEEDINGS OF ELECTRICAL ENGINEERING CAPSTONE SHOWCASE (EECS 2020)
SCHOOL OF ELECTRICAL ENGINEERING, UNIVERSITI TEKNOLOGI MALAYSIA
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SMART CALORIES

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ABSTRACT : Food waste issues had become a norm recently in the School of Electrical (SKE) cafeteria. This issue had brought a negative impact to the SKE environment such as the bad smell release as the food waste accumulated. Plus, the food waste will trigger insect growth around SKE due to the food waste problem. Not to mention, there is a huge amount of food wasted over months. In order to solve this problem, this project had interviewed SKE users to understand users' points of view and collect the main reason for this problem. The interviewees told that food waste is happening mainly because of the overtaking of food portions. Among the majority of SKE users, they throw away their food once they realize they cannot finish the food taken. Thus, this project proposes a Smart Calories system involving hardware and software implementation to solve the issue. To avoid food overtaking, a food ordering process is the main focus of this project. The Smart Calories system is designed to help SKE users calculate the amount of food needed by their body so that the system will suggest the food amount intake. The calories needed by individuals are different therefore, specific calculations are involved in this project. In turn, SKE users will be aware of how much food is needed during the ordering process to eliminate the overtaking issue which resulted in food waste accumulation.

Keywords: Cafeteria; Calory calculation; Food waste

1.0 INTRODUCTION

Sustainability is meeting our own needs without compromising the ability of future generations to meet their own needs. In addition, a sustainable system one whose attributes stay within an acceptable range of states between different parts of sustainable farming will have to optimize to provide sustainability. Smart calories app is an app to control calories needed for a user and a smart spoon that able to measure the portion of users' intake. This trend provides an advanced healthy lifestyle while can help to reduce food waste as well as brings benefit to the users. Smart calories app is predicted to prevents pollution caused by overtaking food portion and offer good health develop from eating well and balance.

In university life, unhealthy eating habits and always getting over portions always happens. This is because the students do not have their own facilities and time to prepare food. Due to these cases, it is the reason why the food waste keeps increasing within time. Therefore, in this project, we are given the scope on handling the wastes material in the School of Electrical Engineering (SKE). To find the main problem and propose a solution, a few steps are involved in this project. The process started with conceiving stage, where at this stage it is expected to find the main problem from the interview session. The next process is a define stage, where all the data from the interview session have been extracted, clustered, and develop a design statement. A prototype was developed in the third stage and been presented for this project.

During the first stage, the interview session was conducted in the School of Electrical Engineering (SKE), which involved students ranging from 20 years old to 24 years old. From the interview session, it is proved that there is a lot of waste material that produced due to the daily requirements from classes, canteen, and laboratory from students and lecturers as users. Examples of waste materials are organic waste, electronic waste, recycle waste, and food waste. After that, in the second stage data that have been gathered from the interview session have been clustered based on users' background, needs, and pain points. Based on this, food waste is chosen to be solved in this project since food waste happens every day due to food that has been taken is not finished.

The remainder of this paper is structured as follows. Section 2 presents the prototype development of this work. Section 3 discusses how the system is operated. After that, Section 4 shows the initial results and discussion from the system, and finally, Section 5 concludes this paper.

2.0 PROTOTYPE DEVELOPMENT

2.1 CONCEIVING

Ice-breaking is conducted to get to know each team member and develop a team contract. Thus, every member needs to give all commitment and shows integrity towards completing this project. For example, the meeting time was decided twice a week which is on Monday from 2.00 pm to 5.00 pm and Friday 9.00 am to 11.00 am thus every team member should complete the given task before next coming meeting. Hence, the project development process will be more efficient and can finish according to the deadline.

Waste material in Malaysia was discussed then the scope is focused at the School of Electrical Engineering (SKE). From the discussion, the example of the waste materials in Malaysia are organic waste, electronic waste, recycle waste, and food waste. Food waste is the main focus of this project since it is the most common problem at SKE. To understand the situation and find the main problem due to this food waste problem, interview questions were developed. The process started with all team members need to develop 10 questions related to the food waste situation at SKE excluded demographic questions. After that, each member presented the questionnaire using an Excel sheet. The color-coded method as shown in Figure 1 has been used to group the questions that have a similar meaning. After this filtering process, interview questions were ready, and the interview session can be conducted. This interview process is known as a semi-structured interview where it is suitable for beginners and people who never conducted an interview before. The interviewees were selected among SKE's students, lecturers, and owner of the cafeteria.

Figure 1: The color-coded method for the question compilation

Next, all the outcomes for 10 questions that have been through the interview session need to be extracted using the data extraction method. Each member extracts any point that they think important from the interview scripts as shown in Figure 2. After that, the extracted data was clustered based on background, needs, and pain points. Any data that is not related was ignored. Based on this data clustering method, a personification was developed.

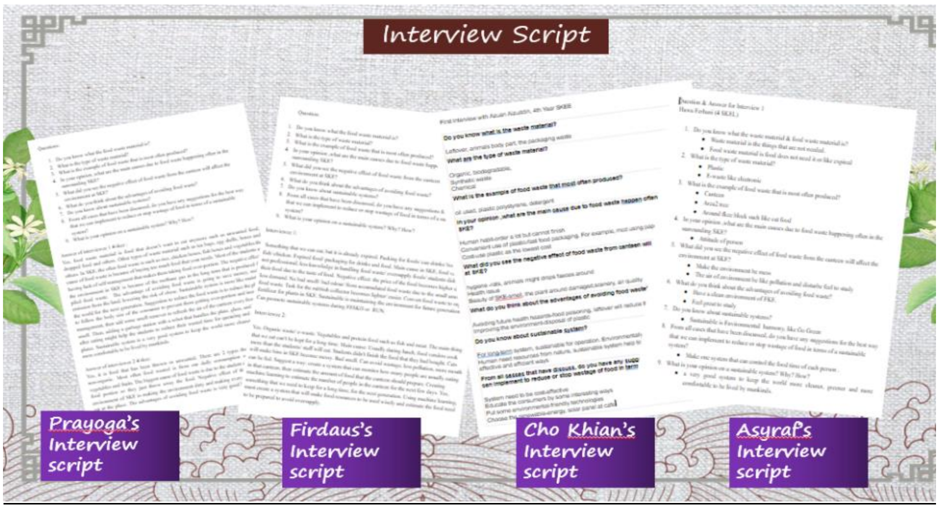

Figure 2: Interview Script

2.2 DESIGN

The design process was started by referring to the design statement that has been developed based on personification in the previous stage. The design statement that was agreed for this project is:

How we may help UTM's students to get healthy food and reducing food waste in UTM?

Based on this design statement, each member needs to sketch their ideas within a certain time given by the supervisor. This process was repeated three times before all members combine their ideas to come out with one proposed solution. The filtering idea is based on STEEP analysis. The summarize of the STEEP analysis that was considered in this project is tabulated in Table 1.

Table 1: STEEP analysis consideration

Aspect	Discussion
Sociological	• Community more awareness about food waste. • The lifestyle of the social community became healthy. • Consumer buying patterns for grocery change.
Technological	Advanced technology by using a smart system. • User friendly and easy to handle. • Innovation from other products to be more effective.
Economic	Low maintenance cost with more quality of crops. • Suitable price. • To promote sustained culture. • A sustainable economy will grow.
Environmental	Minimizing water and soil pollution, sustaining the environment. • The water like the sea and river will clean. • Global climate change.
Political	Powerful tools to enhance the sustainable development of agriculture. • Ensure healthy lives. • Promote well-being for all of all ages.

2.3 PROTOTYPE DESIGN

Based on the design that has been filtered in the previous stage, the proposed solution that has been decided is a calorie calculation and suggestion app with a weight measuring spoon to support the calculation in the app. This proposed solution is expected to solve the problem of taking over portion food and end up unable to finish it. The proposed solution is named Smart Calories.

The Smart Calories consists of two important parts which are the hardware and software parts. The Arduino Nano will be the main microcontroller to the weight sensor, HX711 Module, and OLED Display as shown in Figure 3. The Smart Calories can accept input from users to calculate their BMI (Body Mass Index) and show a food menu to the user while also helping in the meal payment process.

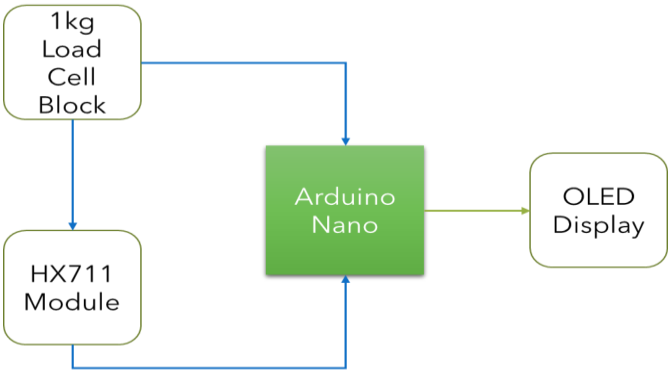

Figure 3: Functionality of OLED display

The Smart Calories consists of several components and sensors such as 1kg Load Cell Block Weight Sensor, HX711 Module, Arduino Nano V3.0, 0.91" OLED Display, and any spoon that can be attached to our hardware system. All components will be placed inside an ABS (Acrylonitrile butadiene styrene) plastic casing with dimensions of 100 x 60 x 25mm. The hardware part is illustrated in Figure 4 while the schematic diagram is shown in Figure 5.

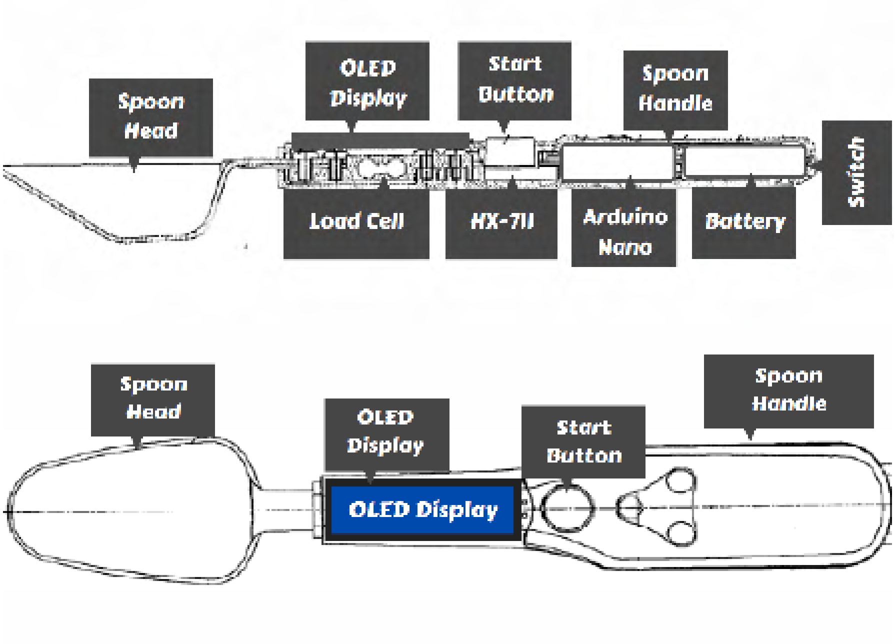

Figure 4: The architecture of the hardware part of the Smart Calories

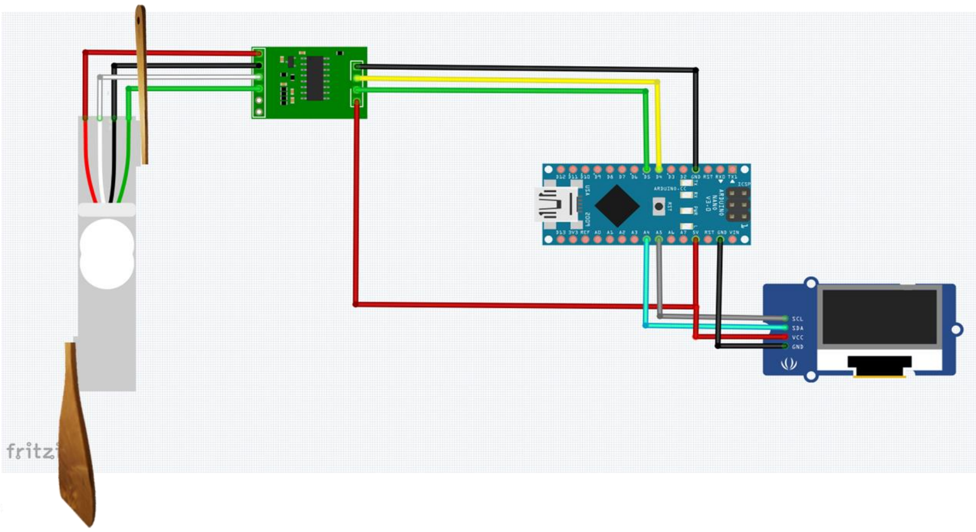

Figure 5: Schematic diagram of the hardware system

2.4 PROTOTYPE DEVELOPMENT

As shown in Figure 6, all components have been assembled and placed in the ABS casing. Whilst the exterior look of the prototype is depicted in Figure 7. The biggest challenge in this part is where to place and how to manage the cable thus it will be easier for any maintenance in the future. The 1kg Load Cell Block can be easily attached to any spoon, ladle, and spatula. Therefore, this is the advantage of this prototype.

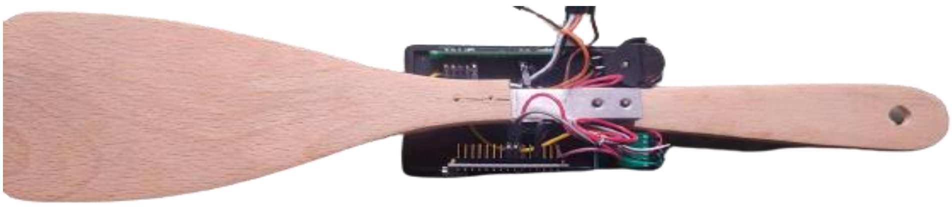

Figure 6: The Interior Design Hardware System

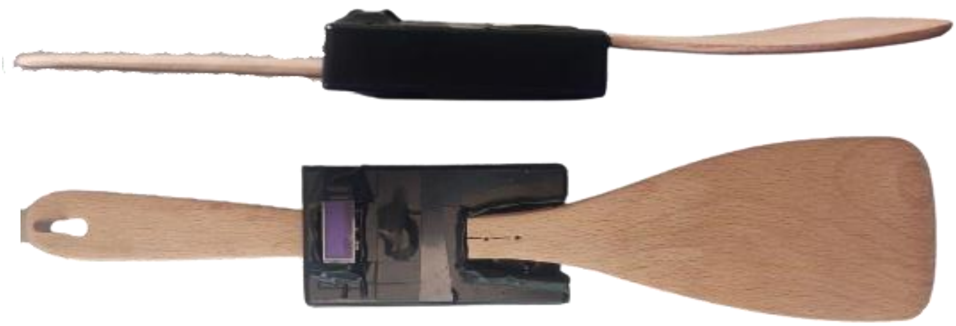

Figure 7: The Exterior Design of Hardware System

The OLED Display is the only component that can be observed from the exterior of the hardware system. The OLED Display gives the output of the weight of food that was placed on the head of the spatula.

The weight sensor is calibrated by measuring terminals between E+ and E-, A+ and A to match the resistance value based on its specifications. The value of resistance between these terminals is 1000 Ω. Next, a calibration factor using Arduino IDE needs to be found. After the coding was uploaded into the Arduino Nano, the serial monitor can be used to test the load cell by placing a known weight on top of the load cell. The best calibration value that can be achieved for a 1 kg Load Cell was 1982.54.

3.0 SYSTEM OPERATION

Smart calories are designed to ease the food ordering process. When the user goes to the SKE, they will input their body information such as weight, height to calculate the BMI. Also, age and the frequency of exercise per week will need to be involved in the calculation process. This calculation gives the number of calories needed by the users' bodies. The calories amount needed calculations are determined by the scientific source Harris-Benedict formulation. To this extent, users will have the specific calories number according to their body condition and their exercise frequency. After they input valid data and obtain the right calories amount required, they will proceed to the menu page. In the menu display, there will be choices of food. Information about the food and the number of calories are ready on the display. Users will know how many calories the food carries among the selection in the menu. The information was researched through food sources from the official web according to Malaysia standards. Users can pick the combination from the menu to decide what they want to eat. Other than that, the price of the food and the weight to match the calories was listed together on the same page. Users can decide the food for their meals based on the menu. At the same time, they will not overtake the food since the estimation is dependent on their body requirements. They can eat at the right portion and this ensures a healthy eating habit among SKE users. Figure 8 illustrates the flow chart of the Smart Calories.

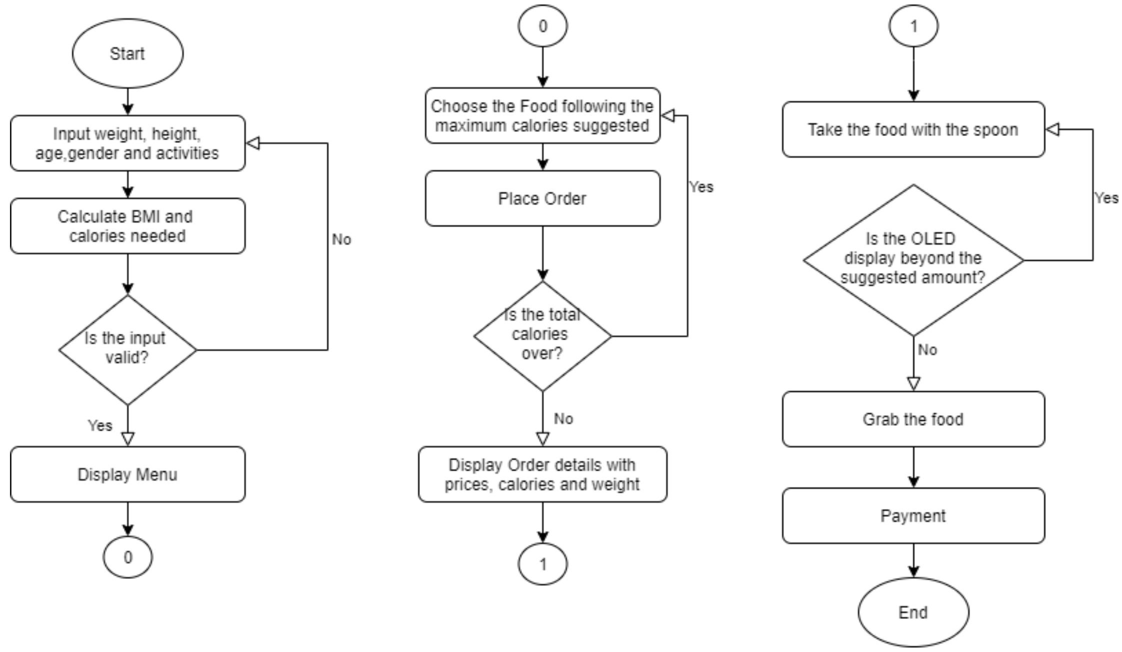

Figure 8: The flowchart of Smart Calories operation

Moving forward after the food selection is done, the food order page will display the amount of food selected in total and the calories available for the user as shown in Figure follows. This page will tell the total amount of the food selected in terms of food prices, food calories, and the weight of the food needed respectively. The last row will display the available food calories to be intake by the body. The interface is depicted in Figure 9.

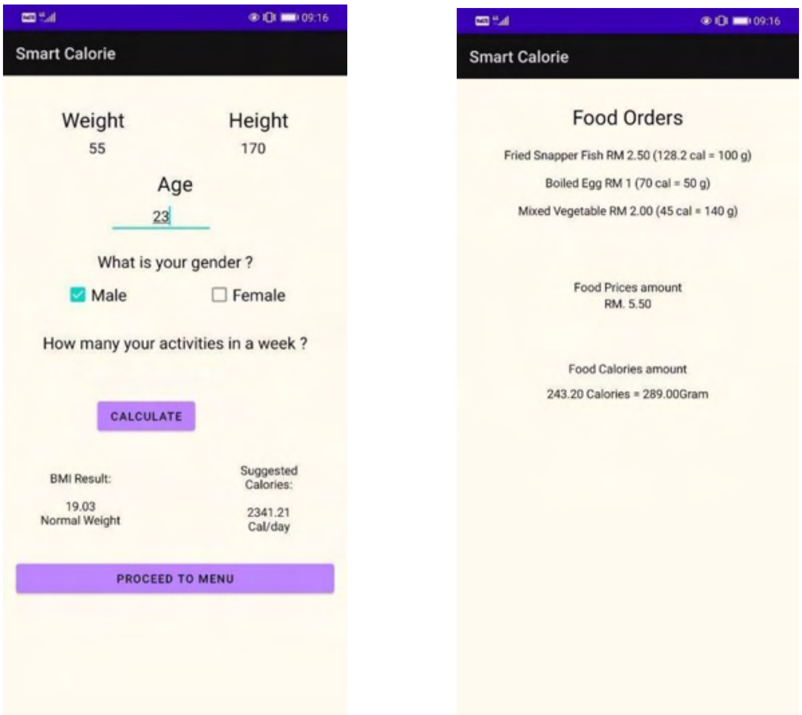

Figure 9: Interface of the list of food order

After this stage, the selected food will be taken with the spatula designed which can show the weight of the food. This is to make sure the amount of food picked is at the right portion. The spoon can take the food at the desired amount as shown in Figure 10. Lastly, payment can be done based on the total price shown to complete the food ordering process.

Figure 10: The spatula to take the amount of food based on the app

As a result, the entire Smart Calories system can be implemented to ease the problem of food selection at the SKE canteen. Users will be able to take the amount of food needed by their bodies.

4.0 INITIAL RESULT AND DISCUSSION

4.1 SOFTWARE PART

The weight and height data is using metric units. The age is using year and the activities are divided into fives types of activities that are no activities, 1 - 3 times exercise in a week, 3 - 5 times exercise in a week, 5 - 7 times exercise in a week, and intense exercise (2 times in a day). The display of the input page is shown in Figure 11.

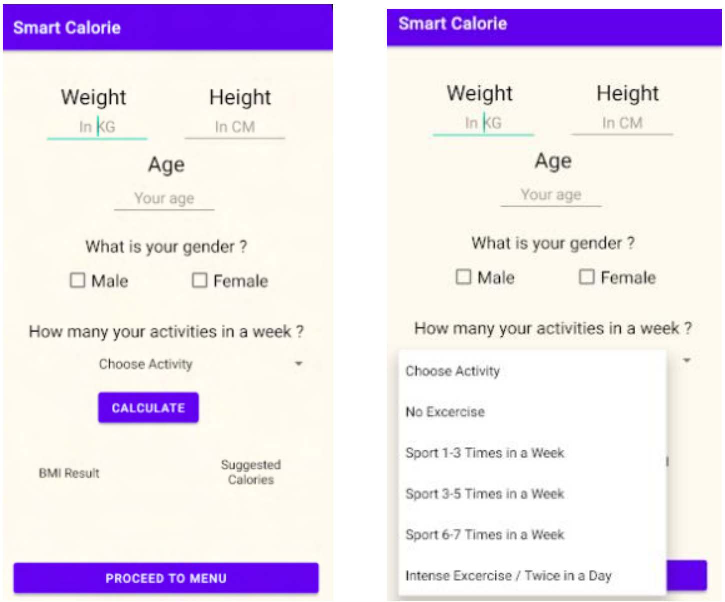

Figure 11: Input data display

Initially, two pages of menu and input data were prepared, then were combined into one application. This method was difficult due to unfamiliarity with the language. To study the solution takes one week of trials. By following the simple example, the pages were able to combine and update the menus following SKE's cafeteria typical menus, calories of each food, and price of the food shown in Figure 12.

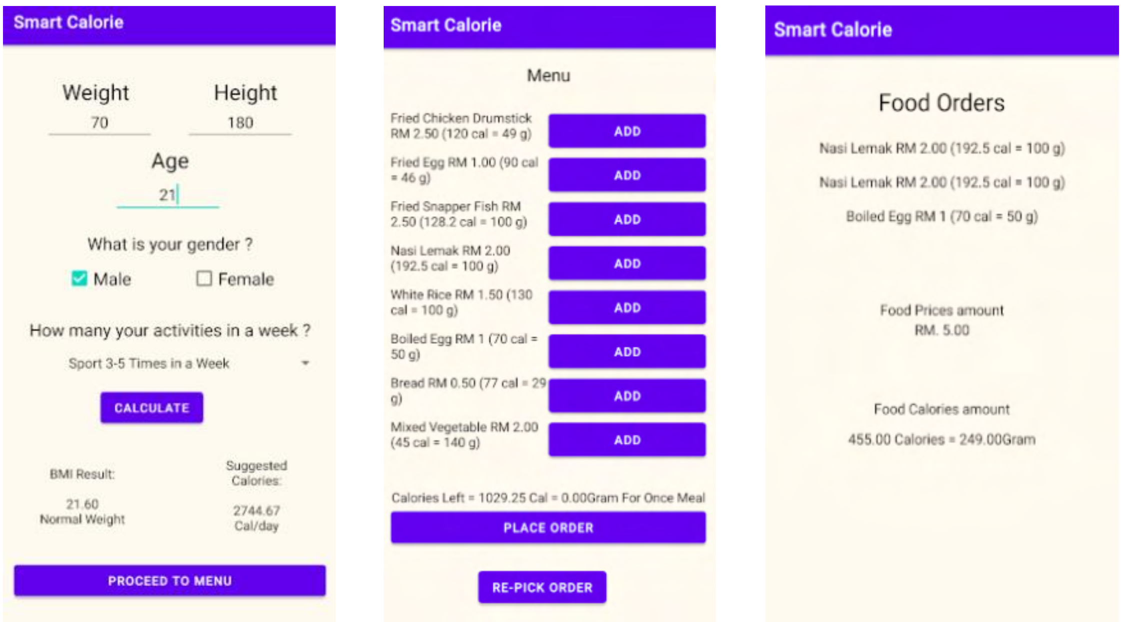

Figure 12: Updated input data, menu, and payment page

All of this data was taken from myfitnesspal and nutrition facts. It is open-source to be explored and the price is following the market price in Malaysia. The calculation is using Harris - Benedict formula to calculate the calories needed that is:

For men:

BMR = 88.362 + (13.397 × weight in kg) + (4.799 × height in cm) - (5.677 × age in years)

For women:

BMR = 447.593 + (9.247 × weight in kg) + (3.098 × height in cm) - (4.330 × age in years)

Then this BMR will be times with the ratio following activities done in a week that is:

No activities	: BMR x 1.2
1 - 3 times exercise in a week	: BMR x 1.375
3 - 5 times exercise in a week	: BMR x 1.55
5 - 7 times exercise in a week	: BMR x 1.725
intense exercise (2 times a day)	: BMR x 1.9

Then the calculation of BMI is simply using the height and weight of the user. The formula is shown below:

$$BMI = \frac{weight\ (Kg)}{height\ (m)^2}$$

With these calculations, the needed calories for the user are controlled and able to reduce food waste.

4.2 HARDWARE PART

For the hardware part, a smart spoon was used to measure the portion of food taken by the user. The user will use the smart spoon after the details of the order have been displayed on the screen of their app as shown the Figure 13. The user needs to take the food as follows the weight suggested by the Smart Calories app by looking at the OLED display.

Figure 13: Sample amount of food taken by smart spoon according to the value suggested by the Smart Calories app

The Smart Calories analysis is done on how the smart calories app and the smart spoon works in actual working. Smart Calories is expected to operate well if the user fills up the correct details of input in the Smart Calories app and uses the smart spoon according to take the food with the value suggested. The user needs to pay attention on how the Smart Calories works, thus the goal can be achieved. Advanced analysis such as comparing why to use the Smart Calories rather than other apps as stated in Table 2.

Table 2: Comparison between the Smart Calories app with another app

App	Smart calories	MyFitnessPal
Measure body BMI	√	√
Give food intake suggestion	√	X
Auto calculate the food calories chosen	√	X
Aware of food amount intake	√	X
Works with weight sensor hardware	√	X

5.0 CONCLUSION

In order to achieve a sustainable system in SKE, interview sessions were conducted with the students, lecturers, and owners of the SKE cafeteria to get an idea of how to reduce food waste in the SKE P19A cafeteria. This project was done by developing a food ordering app known as the Smart Calories using android studio and building a spoon scale using an Arduino micro-controller and load cell. The food ordering app is used to control, giving maximum suggested calories for the user and to support the spoon scale measurement. The spoon scale is used to measure the food's weight following the ordered menus of the user. Thus, with software and hardware development, the Smart Calories is expected to reduce food waste and support a sustainable environment in the SKE.

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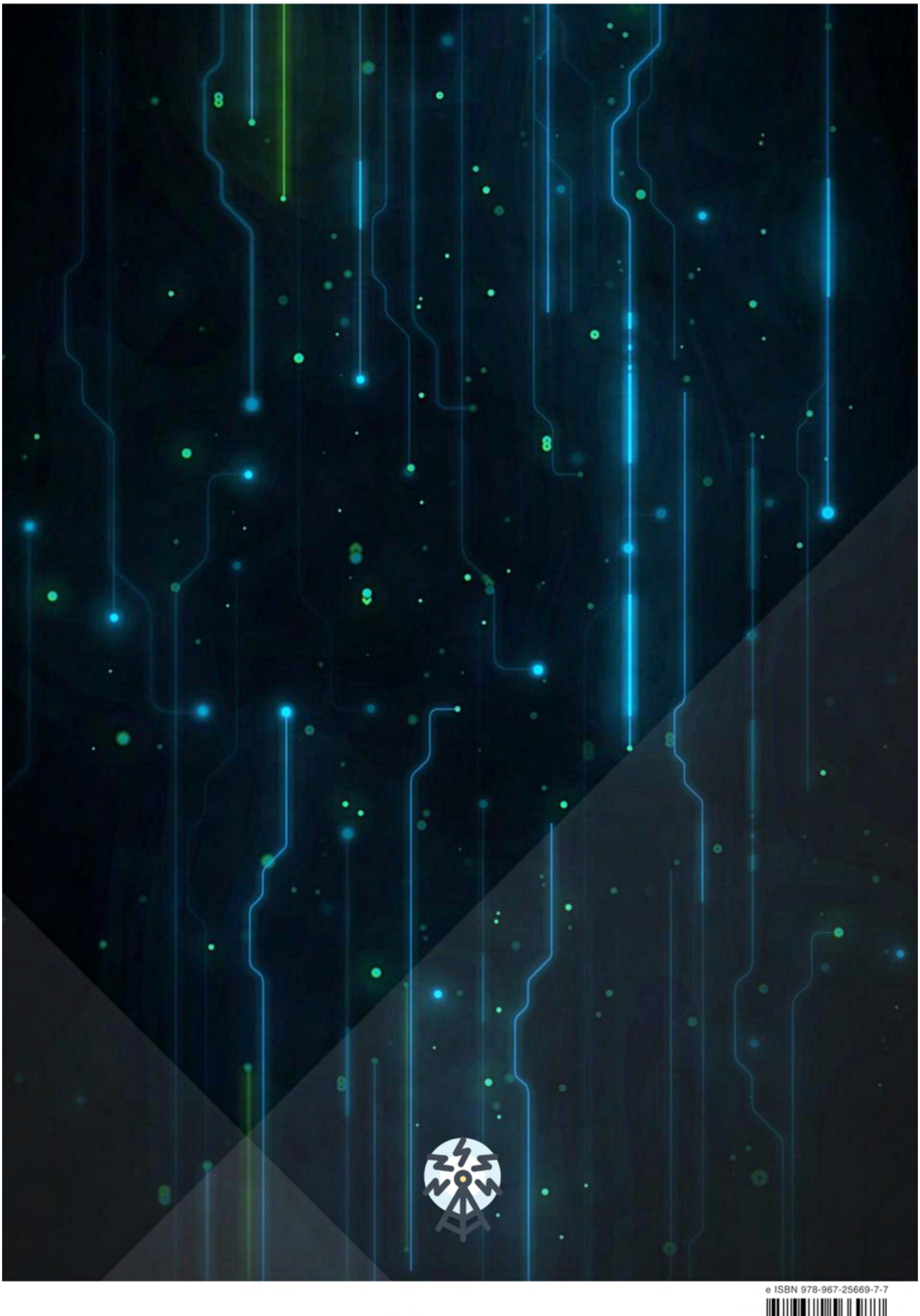

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