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# Prototyping Smart Dustbin Using Arduino Uno Devices

**Ng Chee Ping**[1] **& Lee Te Chuan**[1,*]

[1]Department of Production and Operation Management, Faculty of Technology and Management, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor, 86400 MALAYSIA

* Corresponding Author

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**Abstract**: Ignorance disposal problem of overflow waste materials bring a lot of negative impacts in our society such as attract disease carrying vector, generate foul smell and breed mosquitoes. The purpose of this research is prototyping an IoT-based smart dustbin using Arduino Uno device to reduce the stated problem. There are two objectives for this research, which are (i) to design a prototype of IoT-based smart dustbin embedded with Arduino Uno, ultrasonic sensor, buzzer and ESP 8266 Wi-Fi module, and (ii) to evaluate the product performance of smart dustbin from local restaurant authority using survey questionnaire. Through concept-screening matrix, Arduino Uno, ultrasonic sensor, ESP 8266 Wi-Fi module, buzzer and public bin were selected to develop IoT-based smart dustbin. Integrated Development Environment (IDE) software was used for editor coding, while Thing Speak received real time data from ESP 8266 and If This Then That (IFTTT) was used to send notification for collection centre. Additionally, survey questionnaire had been used to measure product performance. Respondents are those manage or worker who work at restaurant brand or restaurant owner at Batu Pahat. A total of 14 restaurant questionnaire was collected. The results shows that 6 cm or less than is most suitable distance because provide extra space to throw rubbish because the dustbin might not be cleared immediately. Vegetable, paper boxes, paper, plastic, poly foam, glass and mix can be detected by ultrasonic sensor. The results from the survey shows that 10 out of 14 respondents indicate very satisfied system functionalities of the product. Besides that, 8 respondents recognized that product has extremely potential for launching to the market. With the limitation of using Universal Serial Bus (USB), future researchers can prototype smart dustbin using solar panel or battery. In conclusion, this IoT-based smart dustbin has great potential toward development of smart city and Industry 4.0.

**Keywords**: Smart dustbin, Thing Speak, Arduino Uno, Ultrasonic sensor and ESP 8266 Wi-Fi module

**Corresponding author: tclee@uthm.edu.my*

## 1. Introduction

Ignorance towards disposal problem of over rubbish of dustbin around us, it will bring risk of negative impact on public health. For example, it generated foul taste lead to difficulty breathing for nearby residential (Shaikh *et al.*, 2017). Additionally, these foul tastes easily attract flies and rats cause increase the probability risk of disease for public.

Eco efficiency of manage disposal garbage system is one of the challenges faced by majority of the country including Malaysia (Kumar *et al.*, 2017). Conventional technique disposal collects of waste material tendency toward insufficiency and inefficiently because it requires more manpower, time as well as cost (Bajaj & Reddy, 2017).

### 1.1 Research Background

Emerge novel dustbin that combine with high technology (Internet of Things) to increase efficiency, systematic of management and simultaneously leads the country slowly march towards developed country status (Omar *et al.*, 2016).

Therefore, design smart dustbin utilizes devices (sensor) with IoT. The devices consistently monitoring, update the status and automatically transmit information when capacity reaches the maximum level in the dustbin to the responsible authority via wireless network (Gupta *et al.*, 2019).

Hence, it does not need any human effort to go through every dustbin to check content of dustbin. On the other hand, authority concerned priority will aware of which dustbin reaches the specify threshold value to elastically arrange schedule rather than just changed it randomly (Shukla & Shukla, 2017).

In this study, prototype smart dustbin used ultrasonic sensor, Arduino Uno and ESP 8266 Wi-Fi module. Function of sensors

### 1.2 Problem Statements

Population continuous growing which also will increase four percentage year by year meanwhile amount of waste material sustain increase (Mohamad Taha, 2017). Hence, it requires to recruit a lot of manpower as well as time crevices wasteful to meet increase demand on service.

Other than that, flat, rural area and restaurant who commonly share curb side dustbin often facing problem excessive rubbish in the dustbin. It will make public direct thrown waste materials on the street It cause bad impression and influence aesthetic for tourist and consumer (Sembiring & Nitivattananon, 2010).

Besides that, mosquitoes easily breed inside waste material that has stagnant water during rain seasons. It brings numerous severe and contagious diseases for the nearby people such as cholera and dengue fever (Gupta *et al.*, 2019). Moreover, bad smell of food waste easily attract files and rats foraging. It will cause environment become more dirty and insalubrity (Zakaria, 2018).

Kentucky Fried Chicken (KFC) at Parit Raja often faced problem of too much garbage bag. According Figure 1 (i) shows afternoon contain of garbage bags only approaching half of quota while another pictures (ii) of shows garbage bag overflow as well as place garbage bags at surrounding of dustbin. It easily attract rats, dogs, cats search for food. It also will attract many flies due to its bad small. It will cause environment to become unhygienic and unsanitary. Additionally, it will affect quality of food and bad impression for consumers.

1.3 Research Questions

(i) How to design a prototype of smart dustbin?

(ii) Does product performance of smart dustbin satisfy local authority for restaurant?

1.4 Research Objectives

(i) To design a prototype of IoT-based smart dustbin embedded with Arduino Uno, ultrasonic sensor, buzzer and ESP 8266 Wi-Fi module.

(ii) To evaluate the product performance of smart dustbin from local restaurant authority using survey questionnaire.

1.5 Significance of the Study

This study is executed provide convenience for garbage collection company by automatically transmit information of which area dustbin should be collected and reducing the problem of over spill waste material outside dustbin. Hence, it will provide hygiene environment for public due to reduction of mosquitoes, files, rats and stray's animal come breeding and foraging.

1.6 Scope of the Study

(i) Use C++ language to instruction run the function of smart dustbin.

(ii) Survey questionnaire was used in order to understand the response for product.

(iii) The cost of smart dustbin is RM 100.

## 2. Literature Review

2.1 Existing Products

*(a) London High Tech Recycling Bin*

- Provide information for passer-by such as weather, news or travel news, stock exchange and advertisement.
- Green color covered hole is for throwing papers and newspaper.
- Circle hole is for throwing of plastic bottle and cans.


**Figure 1: London High Tech Recycling Bin.**

*(b) Big Belly Automatic Trash Bin*

- Automatically transmit data to the municipal authorities when level of garbage reaches the limit.
- Update real-time information for truck driver to prevent repeated collection trash via Global Positioning System (GPS) (Gaddam *et al.*, 2018).
- Automatic open cover when human approaching (15cm to 20 cm) to throw dustbin.

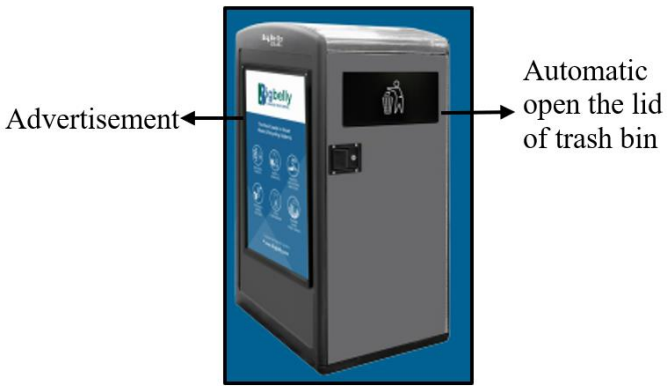


**Figure 2: Big Belly automatic trash bin**

*(c) Big Belly Solar-powered Trash Bin*

- Use solar panel provide power supply.
- Automatically compaction when fill-level sensor detects waste material reach the maximum level.
- Can compress five to eight times.
- Light-emitting diode make notification for public.


**Figure 3: Big Belly solar-powered trash bin**

*(d) Clean CUBE Trash Compactor Bin*

- Immediately stop operation of compressing when detected user throwing waste into bin (ECube, n.d.).
- Fire alarm system detect fire inside bin.
- Light-emitting diode indicate alerts when inner bin reached certain concentration of flame.
- Notification where area of bin happen fire through e-mail or short message service (SMS) (Zackarias & Sangeetha, 2018).


**Figure 4: Clean Cube trash compactor bin**

*(e) Artificial Intelligence (A.I) Smarter Recycling*

- Automatically distinguishes plastic cup and differentiate it to its predefined categories.
- A.I camera automatic recognition the image and scan “chasing arrows” triangle symbol.
- Therefore, notify user correct hole by lighting up the LED around the hole.


**Figure 5: Artificial intelligence smarter recycling.**

## 3. Research Methodology

### 3.1 Sensor Measure Level of Waste Materials

Ultrasonic sensor is the cheapest device with RM 5.00. Infrared sensor as the second with RM 6.00. The highest costly is motion sensor with RM 7.00.

Ultrasonic sensor maximum distance to detect is 100 cm (Adarsh *et al.*, 2016) and accuracy level around 90 to 97 percentages (Mohammad, 2009) whereas infrared sensor maximum range is 80 cm (Adarsh *et al.*, 2016) and accuracy only around 92 percentages to 95 percent (Mohammad, 2009). Motion sensor only can detect range an object within 7m ("HC-SR501 PIR motion detectot," n.d.).

Through Table 1, it shows ultrasonic sensor is the best devices for detecting distance. It is because ultrasonic sensor has reasonable price, longest distance and highest reading accuracy.

**Table 1: Sensor concept-screening matrix**

| Criteria | Components | | |
|---|---|---|---|
| | **A** Motion sensor | **B** Ultrasonic sensor | **C** Infrared sensor |
| Price | - | + | 0 |
| Maximum distance to detect | - | + | 0 |
| Accuracy level | 0 | + | 0 |
| Display data | - | + | + |
| Sum +'s | 0 | 4 | 1 |
| Sum 0's | 1 | 0 | 3 |
| Sum –'s | 3 | 0 | 0 |
| **Net Score** | -3 | 4 | 1 |
| **Rank** | 3 | 1 | 2 |

### 3.2 Final Design

Arduino Uno, ultrasonic sensor, ESP 8266 Wi-Fi module and 5V buzzer were chosen for final design project and shown by Figure 6.

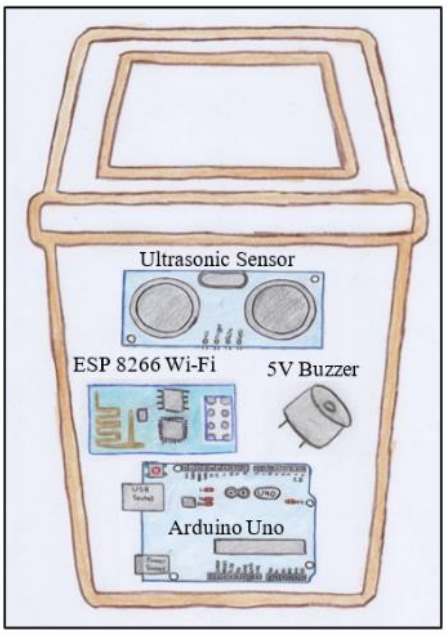


**Figure 6: Final Design Project**

### 3.3 Platform

*(a) Thing Speak*

Thing Speak is a free and paid pricing schemes platform (De Nardis, Caso, & Benedetto, 2019). Free account only can create maximum four channels for visualization, collecting and store data in the cloud. It able to receive data from any devices such as Arduino Uno, Raspberry Pi and Node MCU (Nasution *et al.*, 2019). Additionally, it able to show location and watch the video on the channel.

*(b) If This Then That (IFTTT)*

IFTTT is a free web page service. It provides free services to get your apps and devices communicate with each other. It automatically do the process without human assistance.

*(c) Virtuino MQTT*

It is the mobile app. User able to see real time data from Thing Speak through mobile.

### 3.4 Survey Questionnaire

For better understanding does the smart dustbin prototype met the market requirements, survey questionnaire section is conducted. The target respondent are those worker, supervisor and manager who is incharge in brand restaurant or restaurant owner. Fourteenth restaurant nearby at Batu Pahat, Johor as respondents to evaluate product performance. The purpose is improvement that want to add on the smart dustbin after collecting data.

## 4. Data Analysis and Results

### 4.1 Assembly Components of Smart Dustbin

Assembly components of smart dustbin shown by Figure 7. First, assembly ultrasonic sensor which contains 4 pins namely, collector supply voltage *[VCC]*, trigger *[Trig],* echo and ground *[GND]* from left to right. Power supply (5V) on microcontroller connected to VCC. Trig pin connected to pin 2. Echo pin connect to pin 3. Lastly, GND pin connect to ground pin.

Second, assembly of ESP 8266 Wi-Fi module which contain 6 pins (receive data bit *[RX],* collector supply voltage *[VCC]*, general-purpose input/output no 0 *[GIPO 0]*, reset *[RST]*, general-purpose input/output no 2 *[GIPO 2]*, chip power-down *[CH_PD]*, transmit data bit *[TX]* and *ground [GND]*). RX and TX connect to 10 and 11 pins respectively. VCC and CH_PD connect with 3.3V. GND connect to ground pin. Third, assembly of buzzer. Positive pin connected to pin 12 while negative pin connected to ground pin.

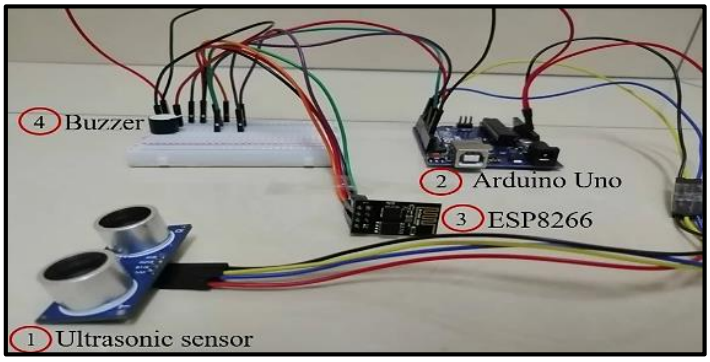


**Figure 7: Actual diagram.**

## 4.2 Testing Distance Send Notification

The purpose is defining appropriate distance send notification to cleaners. Figure 8 shows, 16 cm not appropriate because garbage bin was empty. Second picture (13 cm) also not appropriate because waste material only a little bit. Although next picture already reach half with 10 cm but waste many manpower to clean up the dustbin. 6 cm is the best appropriate distance send notification because there might be no immediate collection from cleaners and provide extra space for the dustbin to collect more dustbin before it spilled out. Whereas 2 cm not appropriate because waste material nearly to spill out.

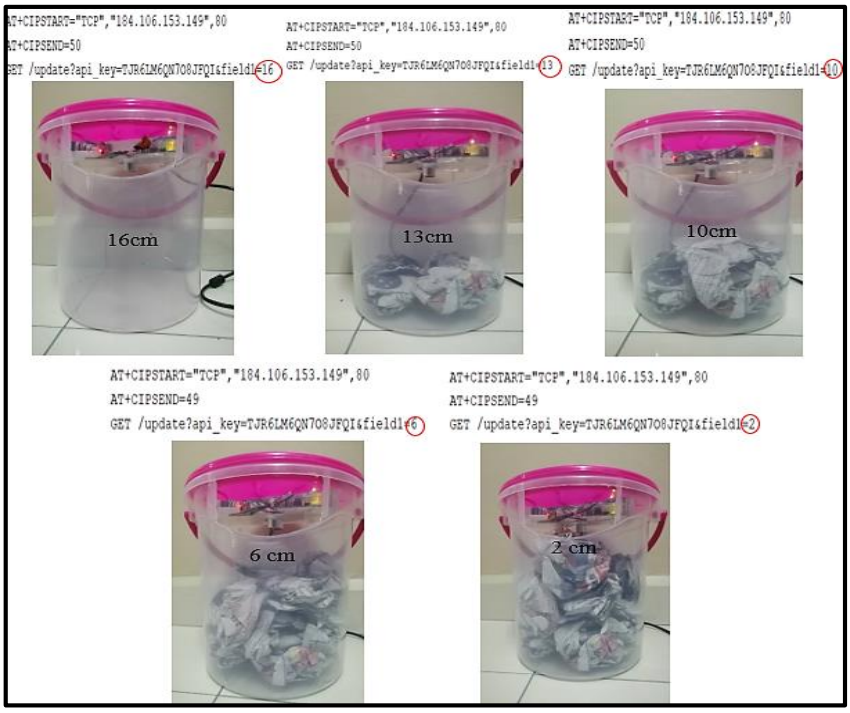


**Figure 8: Distance of send notification.**

## 4.3 Testing Different Types of Material

The purpose of experiment is testing whether several of material can be detected by ultrasonic sensor. The materials used to test are included vegetable, paper boxes, paper, plastic, poly foam, glass and mix. From the testing come a conclusion, all the testing material can be measured by ultrasonic sensor.

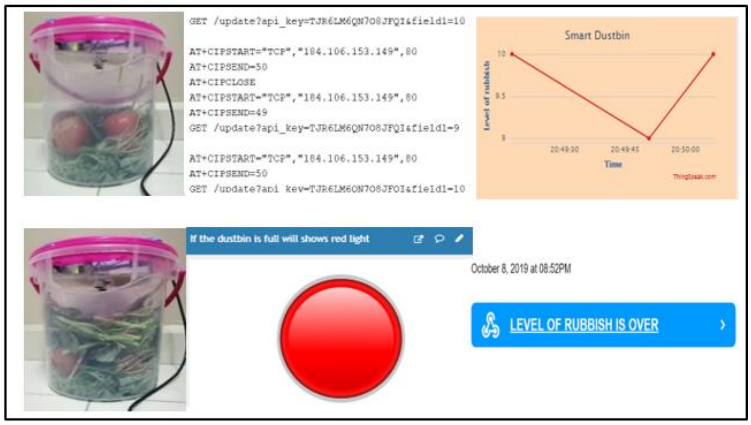


**Figure 9 (a): Food waste.**


**Figure 9 (b): Paper boxes.**


**Figure 9 (c): Paper.**

4.4 Analysis of Market Survey

Gender: Respondents of male and female is 50 % respectively.

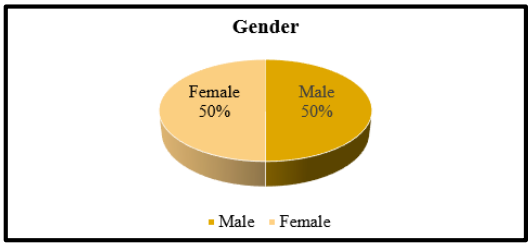


**Figure 10: Gender**

Age: Most of the respondents' age between 21-30 ages meanwhile 31-40 age only have 5 respondents.

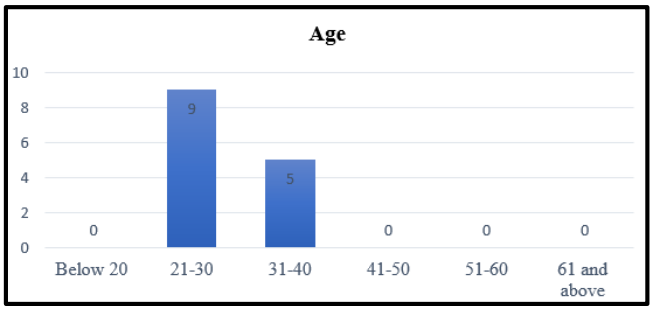


**Figure 11: Age**

Sector of occupation: Worker is the highest number category (7). 4 respondents are manager, 2 are supervisor and only 1 respondent is other.

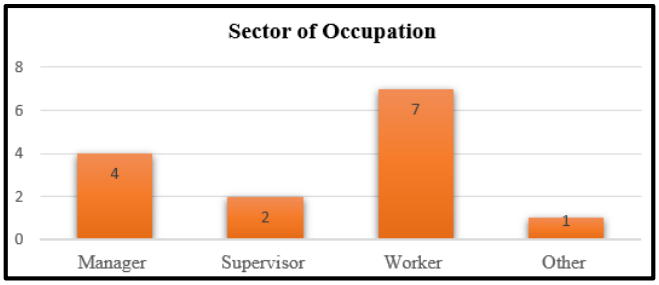


**Figure 12: Sector of occupation**

4.5 Analysis of product performance

Figure 13 shows result of product performance. There are four question on the product performance.

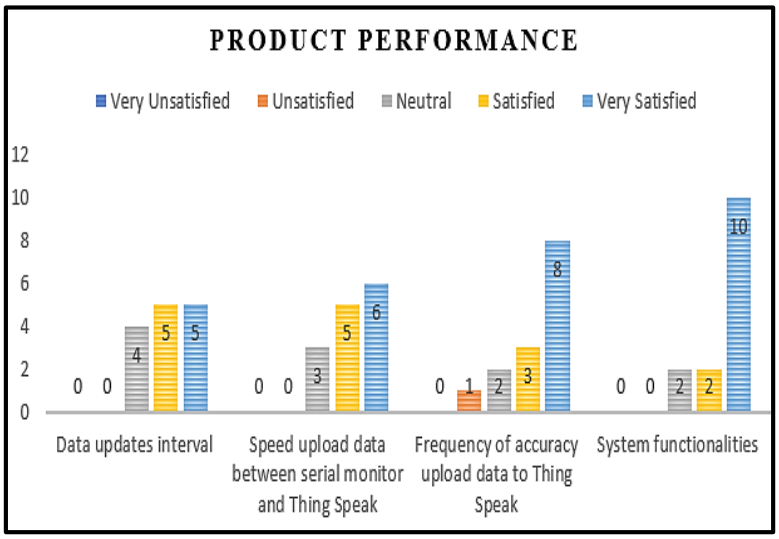


**Figure 13: Performance of smart dustbin**

In aspect of data updates interval, half of the respondents express very satisfied and satisfied. Only 28.57% respondents consider neutral.

In aspect of speed upload data, most of respondents consider very satisfied meanwhile there are 5 respondents and 3 respondents for satisfied and neutral.

In aspect of frequency of accuracy upload data to Thing Speak, one of respondent express unsatisfied. 2 respondents' express neutral and 3 respondents express satisfied. But 57.14% respondents consider very satisfied.

In aspect of system functionalities, most than 50% respondents indicate very satisfied function of Smart Dustbin. 14.28% for satisfied and neutral respectively. System functionalities is the most satisfied criteria among the 4 criteria in product performance.

4.6 Analysis of product quality

Figure 14 shows result of product quality. In aspect requirement, very satisfied obtain the highest rating from respondents with 64.28% meanwhile there are 21.42% and 14.28% for satisfied and neutral.

In aspect of design, most of respondents express neutral. Only 4 respondents express satisfy and very satisfy respectively.

In aspect of weight, there are highest rating with 64.28% for satisfied, 21.42% for very satisfied, 14.28% for neutral.

In aspect of user friendly, 57.14% respondents express Smart Dustbin very easily to use, 21.42% for satisfied, 14.28% for neutral and 7.14% for unsatisfied.

In aspect of reliability, 64.28% respondents express very satisfy, 14.28% for satisfy, 7.14% express neutral, dissatisfy and very dissatisfy respectively. Hence, the product requirement has shown case that it is required for the market.

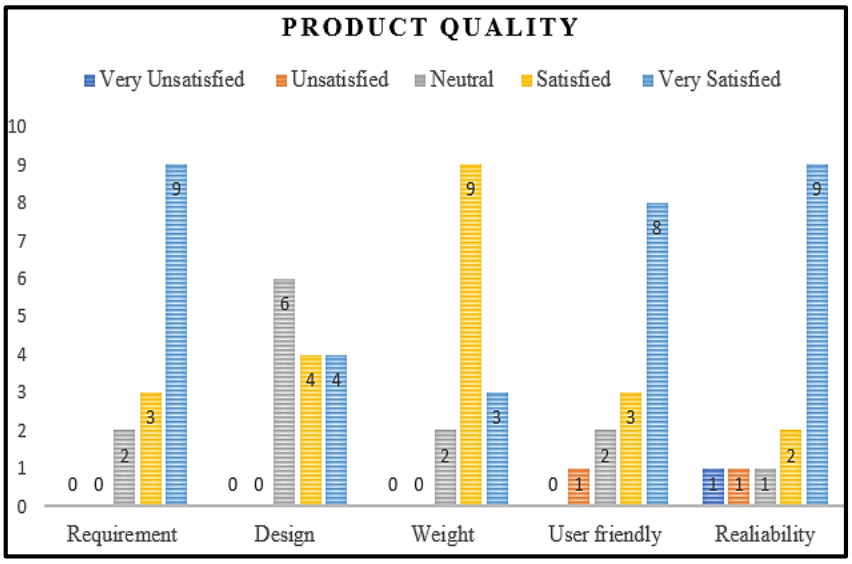


**Figure 14: Quality of smart dustbin**

4.7 Analysis of product response to the market

Based on Figure 15, out of the 4 criteria we can concludes that this product is suitable to launch to the market and restaurant would buy the product if it is available on the market because it is regarded that it would improve the waste disposal of restaurant.

The only improvement required to reconsider is the price of the product as out of 14 respondents, 2 of them is unsatisfied with the price so the price of this product should be re-evaluated.

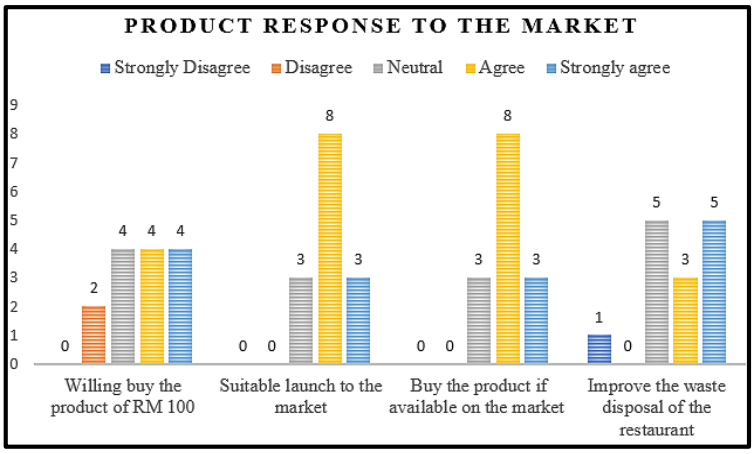


**Figure 15: Response of product to the market**

## 5. Discussion and Conclusion

### 5.1 Achievement of the Overall Objective

Smart dustbin can send notification to garbage collection centre authority when garbage reach threshold level. Besides that, it is used to notify that worker restaurant to clean out the dustbin. Apart from that, it provides real time data to collection centre. So that, collection centre can observe the behaviour of user to make flexible schedule. Therefore, the first objective to design a prototype of IoT-based smart dustbin embedded with Arduino Uno, ultrasonic sensor, buzzer and ESP 8266 Wi-Fi module was achieved.

Although ultrasonic sensor can through types of material such as vegetable, paper boxes, paper, plastic, poly foam, glass and mix to detect the distance between waste materials and sensor, but it exist reading error with less than 2 to 3 cm in the actual value. Besides that, testing for suitable distance send notification to collection centre. The result shows that 6 cm or less than is the most suitable distance to send notification because it has extra space to throw waste materials.

Second objective is to evaluate product performance from local restaurant was achievement. Totally 14 local restaurants were participated in this survey. They are form restaurant which nearby Batu Pahat, Johor. Most of respondents perceived that product has potential on the future market but the design requires improvement on efficiency and efficiently. 10 out of 14 respondents are very satisfied with the system functionalities, while 8 respondents very satisfied with the frequency of accuracy data upload to thing speak. Furthermore, for product quality, 9 respondents perceived that the prototype is reliable and required in the market. Meanwhile for the product response, 8 respondents regard prototype is suitable to launch to the market and will buy it if its available at the market. Overall the function of the product was very satisfied by respondents. However, small part of respondents recognized that product too costly expensive.

### 5.2 Advantages of Prototyping Smart Dustbin Using Arduino Uno Device

- The product is cheaper than currently market available.
- The product provides real time data hence the data is updated frequently.
- The product can view in multi-based, web-based and phone based.
- The product will provide obvious notification to remind the dustbin is full.

5.3 Limitation of Prototyping Smart Dustbin Using Arduino Uno Device

- Slight Reading error (± 3) cm which won't significant impact the performance.
- The product depends universal serial bus (USB) to provide electrical power.
- The product needs internet connection to provide real time service.

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