DESIGN AND DEVELOPMENT OF 2-IN-1 AUTOMATIC PET FEEDER

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DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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This thesis is the result of my own investigation, except where otherwise stated. Other sources are acknowledged by giving explicit references. Bibliography/references are appended.

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LIST OF ABBREVIATIONS

ABS	-	Acrylonitri1e Butadiene Styrene (ABS)
CAD	-	Computer Aided Design
GIT	-	Gastrointestinal Tract
IoT	-	Internet of Things
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
MDF	-	Medium-Density Fiberboard
NPV	-	Net Present Value
SAFE	-	Social, Altruistic, Functional, and Esthetic
VR	-	Virtual Reality

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ABSTRAK

Automatik feeder haiwan peliharaan merupakan satu teknologi baru yang membantu pemilik haiwan untuk memberi makanan haiwan mereka mengikut jadual. Pada masa kini, terdapat banyak orang suka memelihara haiwan di rumah, tetapi pemilik haiwan kesayangan cendurung untuk lupa menyuap haiwan kesayangan mereka. Automatik feeder haiwan 2 dalam 1 adalah feeder yang boleh diprogramkan. Ia membantu pemilik haiwan kesayangan memastikan haiwan kesayangan mereka mempunyai akses jumlah makanan sepanjang hari. Feeder ini mempunyai dua sistem, iaitu sistem makanan dan sistem air. Kedua-dua sistem ini menjalan secara alternatif. Feeder ini direka dan diprogram dengan menggunakan perisian SolidWorks dan Arduino. Pada fasa pertama projek, keperluan pelanggan dikenal pasti untuk mewujudkan spesifikasi dan kriteria produk. Dalam peringkat rekaan, empat konsep produk dihasilkan. Konsep yang telah dimuktamadkan dipilih dengan menganalisis data yang dikumpulkan dalam kaji ujian konsep. Konsep C dipilih sebagai kriteria dan spesifikasi produk yang telah dimuktamadkan kerana ia mempunyai potensi pasaran yang lebih tinggi, iaitu 0.2666666667 berbanding dengan konsep D, 0.2380952381. Konsep baru direkakan berdasarkan spesifikasi konsep C. Analisis ekonomi dibina untuk mengira kadar keuntungan bersih. Kos pengeluaran unit bagi produk dianggarkan sebagai sebagai RM360 seunit dan harga seunit ialah RM560 seunit. Kadar keuntungan bersih bagi empat tahun ialah RM 3,099,000. Projek ini boleh diutamakan sebagai pelaburan disebabkan ia mempunyai kadar keuntungan bersih yang positif. Prototaip produk dibina dengan menggunakan Medium-Density Fiberboard, kadbod, dan komponen-komponen elektronik. Pada peringkat akhir, demostrasi dan ujian fungsi dijalankan supaya feeder dapat mengedarkan makanan dan air dengan sewajarnya.

ABSTRACT

Automatic pet feeder is one of the new technologies that assist the pet owners to feed their pets according to schedule. Nowadays, people loves to keep pets at home. However, some of the pet owners tend to forget to feed their pets. 2-in-1 automatic pet feeder is a programmable feeder which helps the pet owners to make sure that their pets have access an amount of food throughout the day. There are two systems in the feeder, which are food system and water system, where they work alternatively. The feeder is designed and programmed by using SolidWorks and Arduino software. In the first phase of the project, customers' needs are identified to establish the specifications and criteria of the product. In the design stage, four concepts of the product are generated. The finalized concept is chosen by analyzing the data collected in concept testing survey. Concept C is chosen as the finalized criteria and specifications of the product as it has higher market potential, which is 0.2666666667 compared to that of concept D, 0.2380952381. A new concept is designed based on the specification of concept C. An economic analysis is built to compute the net present value of the product. Unit production cost of the product is estimated as RM360 per unit and the unit price is RM560 per unit. The net present value calculated for four years is RM 3,099,000. This project can be used to support major investment as it has a positive value of net present value. A prototype of the product is built by using Medium Density Fiberboard, cardboard, and electronic components. After all the stages, demonstration and functionality test are run as the feeder able to release food and water accordingly.

CHAPTER ONE: INTRODUCTION

1.1 Project Overview

Automated pet feeder is one of the new technologies device to assist the pet owners to feed their pets automatically when they are not around. The users just have to set the feeding time for their pets. This feeder contains two systems which are food system and water system.

2-in-1 Automatic Pet Feeder will be controlled and programmed by a microcontroller, which is Arduino. The program software will identify when the servo motor and stepper motor should run to dispense the food and water. The food will dispense according to the time set, whereas the water will only dispense when the water level is low. The level of water is sensed by using water level sensor.

In addition, liquid crystal display (LCD) will be installed where the pet owners can easily view and track the feeding time. Perspex will be used as the cover of the feeder to make sure that pet owners able to view condition of the feeder and the capacity left in the storage.

1.2 Research Objectives

This project is to design and develop 2-in-1 Automatic Pet Feeder:

1. To enable an easy access for pet owners to feed their pets when they are busy.
2. To ensure pets get fed just right on time to manage their dietary.
3. To dispense the right amount of food and water accordingly.

1.3 Problem Statement

There are a lot of people who love to keep pets. In Asia-Pacific, there are 62 million of household owning a dog in 2011. A rate of 13% dog ownership has increased from 2006 until 2011 (V.K. Lee 2015). Having a pet is an obligation which does not go into waste because it can be as an entertainment and a company at home. However, some pet owners who are working tend to forget to feed their pets. There are some unpredictable situations, such as working overtime, late meeting or short business trip. These situations are causing troubles to their pets.

In all these situations, pet owners have limited options to solve their problems. Some of the pet owners have to send their pets to pet care, or even their relatives or friends to help them to take care their pets. Pet Nanny Malaysia is Malaysia's leading educational organization for professional pet sitters since 2007. They provide pet boarding, pet sitting and training service for pets. According to Pet Nanny Malaysia, rate for 1-hour visits for pets is RM50, whereas for overnight stay is around RM80 to RM150 (P.N 2017). Some pet owners who could not afford their pets to be sent to pet care, they will just leave their pets at home without supervision. Besides that, this might have caused inconvenience for those who have to help them with the chores of feeding their pets.

Therefore, 2-in-1 automatic pet feeder will give pet owners a solution to these problems, thereby providing a pet care system which able to manage the dietary of the pets and improving the lives of both pets and the owners.

1.4 Project Scope

The scope of this project is to identify the customers' needs, thus design the idea of the product by developing a prototype. In this project, customers' needs are identified in the first stage. Data collected are analyzed to establish target specification. three concepts will be generated and one of the concepts will be selected by using concept screening method and concept scoring method. In concept testing, survey will be done to set the final concept. Detail design and material selections will be done in final concept stage. Next, economic analysis includes financial model and sensitivity analysis are performed. Competitive benchmarking will also be performed as it can provide variations of ideas for the product. Finally, a prototype of the product is developed to demonstrate the functionality of the product. A test will be conducted by the users.

CHAPTER TWO: LITERATURE REVIEW

2.1 Product Design

Product design is the technique by which translating customers' needs into marketable product (N.S.A. Derkyi 2018). It is also the first point of contact between the product and the consumer. There are four core theme values in product design, which are Social, Altruistic, Functional, and Esthetic (SAFE). Social value in product design is defined as the capability of helping the consumers increase their apparent rank in the community. For altruistic value, it is about the perception from the consumers on how they able to help other individuals and the society. Functional value is the method of the product helps the needs of the consumers. The attractiveness of the product is valued by the consumers, where this is called as esthetic value. Through this SAFE value scale, it offers an opportunity to puzzle out the configuration of values in a product design (M. Kumar 2015).

To design a food-related product, there are six main steps to design a product. Firstly, assess the customers' needs by interviewing and surveying. After customers' needs are identified, few alternatives of the product design ideas are generated to meet the product specifications. Market study is the most important as it is to study the potential demand of the product. Production process and product analysis are done after the market study. Statistical analysis is done to compute the physiochemical properties of the drink (N.S.A. Derkyi 2018). SAFE value scale must be utilized in a product design project to make sure that the product is valuable to the consumers (M. Kumar 2015).

Computer-aided design (CAD) is one of the tools used in product design. CAD can be used in continuously emerging advanced genetic engineering techniques. This let metabolic engineering to widen the procedure of heterologous compound-production. CAD helps to avoid many of the restrictions with current industrial processes (A.F. Castane 2014).

There are two types of user involvement in design process, which are indirect involvement pattern and direct involvement pattern. Indirect involvement is considering the user to evaluate the function of the product without dealing with the detail design of

the product components. For direct involvement, the user able to see, touch, smell and feel the product. The development of CAD systems improves the traditional design process. However, CAD systems are not enough for the user to feel the product. There is an advanced technology, which is virtual reality (VR). VR technology enables the design undergoes testing and verification in terms of function and performance under an advanced interactive environment. It also provides user a real feeling of product implementation (Z. Zhang 2015).

2.2 Automated Feeding System

The communication between human and physical devices in the real world is getting more attention. There are some abilities of communication and control technologies to improve human communication with pets by technology of Internet of Things (IoT). Pet appliances, such as pet door and pet feeder can be one of the IoT technologies with the capability of tracking pets' location, and to help pet owners raise their pets easily. Smart pet feeder allows pet owners to schedule and remote their pets' feeding time. There will be more pet care system integrated in future such as, litter box and pet cam (C.M. Own 2013). Automated pet feeder aids to reduce waste of food as it dispenses according to time, amount and the demand (B.O. Mattos 2016).

There are automatic pet feeders for pigeon, cats, and monkeys built and tested to dispense a correct amount of food. There are some errors occurred for three types of pet as the pellets for each type are different (J. Oh 2016). Besides that, a self-feeder system with infrared sensor is built for fishes. The occupancy sensors allow to measure the feeding and locomotor activity of the fishes. However, some pets are influenced by a fixed schedule feeding system (B.O. Mattos 2016).

Automated feeders are also widely used in agriculture. It is used as claves weaning feeder to feed large amount of milk. Automated feeders can be used to adjust the weaning based on each calf's willingness. It resulted a reduction of weaning from 12 to 13 weeks old to 6 to 8 weeks old (A.M. Passile 2016).

Arduino is one of the microcontroller types. It is widely and commonly used in many fields, for example home application and domesticated field. For home application,

automatic water tank filling system can be controlled using Arduino and ultrasonic sensor. The water is automatically filled by using the transmission of ultrasonic pulse and speed of sound. Arduino will receive the data and converted the signal recorded by the sensor. The switch will turn on when there is no water in the water tank and it will turn off when the tank is full (E.C. Prima 2017). This concept can be applied on smart pet feeder as the water will be automatically filled up when there is low level of water in the feeding bowl.

Besides that, Arduino is also used in controlling temperature in 3D printer hot-end. The reading of the temperature is read through analog input while the resistor is actuated through digital output by developing a program for Arduino. Arduino can be used in controlling a cartesian robot by developing a program that interacts with the sensors and the actuators. This helps to move the carriage to a chosen target position accurately. The voltage used in Arduino is 5V logic and it is directing the signals from the encoders and other sensors (F. A. Candelas 2015).

2.3 Pet Nutrition

Pet's nutrition is the most important criteria as it prevents pets from obesity, gastrointestinal, indigestion and other sickness. The consequences of obesity is from a lengthy imbalance diet, which energy intake is higher than energy expenditure. To decrease obesity disease, there are few strategies, which includes dietary and lifestyle management, behavioral modification, medical and surgical therapy. Dogs and cats are considered obese when their body size exceeds the ideal body size by 15% and 30% respectively (M. Osto 2015). Therefore, gastrointestinal tract (GIT) of animals and its health are significant factors in determining animal performance (P. Celi 2017). Overweight dogs may lead to many diseases. To diminish the risk of obesity, higher protein diets may help to sustain body weight loss and avoid weight regain (M. Osto 2015). Besides that, protein dietary aids in maintaining the immune homeostasis in the GIT. It also originates from the digestion of various digestive enzymes, or from the processing of the GIT microbiota (P. Celi 2017). In addition, natural diets which contain wholesome ingredients can also reduce the risk of obesity as well as prevent diabetes mellitus (A.D. Cerbo 2016).

Fiber is a relatively indigestible component in feed that can dilute the nutrients and limit the level of feed intake (E. 2017). Thus, dietary fibers provide less dietary energy (M. Osto 2015). It is also well known for its prebiotic effect. It can modulate the immune function and interacts between the diet, endogenous enzyme, and digestion and absorption (P. Celi 2017).

Antioxidants with the presence of elevated levels may have direct metabolic effect in improving animal performance (E. 2017). An antioxidant diet can be used to achieve a better reproductive performance in animals (A.D. Cerbo 2016). It can also assure high quality of their products (P. Celi 2017).

PetFinder.my is an organization in Malaysia that provides the largest listing of dogs and cats for adoption and sale, helping rescued pets in seeking shelter and fosterers. According to PetFinder.my, it is suggested to feed pets twice a day, which is once in the morning and once in the evening. However, for pets that under five months of age should be fed three or four times a day (Petfinder 2017).

PetMD is also an organization that provides the largest library of pet health information with vet approval. They also give advices on pet's symptoms, diagnosis and treatment from their veterinary experts. Based on PetMD, scheduled feeding method and portion-controlled method work well, and it is the healthier method as it limits the amount of food your pet is taking in at each meal. For other considerations, measured and scheduled feeding times can allow the pet owners to monitor their pet, making sure that their pet is eating all his food (petMD 2017).

2.4 Interconnection Between Human and Animals

The nature of the relationship between companion pets and their owner can have an important impact on quality of life for both pet and owner (I. Meyer 2014). The owner and pet's characteristic may also influence their quality of life (L. Marinelli 2006). There are few factors that affect the dog-owner relationship. The behavior of the dog itself is less important for the owner's perception compared to the match between the dog's behavior and the lifestyles of the owner. Besides that, owner is satisfied on a good match between dog and owner with regards to motivating to exercise (I. Meyer 2014). Marital status

(single) influences the level of care of the pets. However, age of the pet, and length of the pet-owner relationship and neutering do not influence the level of care (L. Marinelli 2006). Dog's personality does not have large impact on the dog-owner relationship, but owner himself (I. Meyer 2014). The social life, experiences, and willingness of the owner that mostly affect the condition of the dog. The level of care reduces if the owner owns more than one dog. This is because the dog is less attached to its owner and it feels insecure. The sharing of belongings also affects the level of bonding of the dog (L. Marinelli 2006).

Human and animals come into contact whenever there is an opportunity to interact. There are different qualities and quantities of communication between owners and the animals in their care (H. 2007). The concept of the human-animal relationship is also widely used in farm animal, like horse. The management conditions, such as accommodation, feeding method, and training methods, may lead to relational problems between horses and humans. By using appropriate tools and use of riding aids can help to improve the horse-human relationship as this may reduce the pain of the horses and avoid the bad memories for them. Besides that, developing awareness and attention that given by the horses may help to decrease the risk of accidents happen when (M. Hausberger 2007). On the other side, if the relationship is not strong, there will be initial fear affected on the animals to humans (H. 2007). Therefore, relationships and interaction between human and animals is important as the animals can be a cheerful companion to human.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Research Phases and Steps

The flow chart of the research is shown in Figure 3.1. The details will be discussed in the next section. There are eight stages in this research, which are identify customers' needs, establish target specification, concept generation, concept selection, concept testing, final concept, economic analysis, and modelling and prototyping (K.T. Ulrich 2012). The theme used in this research are Social, Altruistic, Functional, and Esthetic (SAFE) (M. Kumar 2015). The tools used during the research includes pie chart, needs-metrics matrix, function diagram, weightage rating system, cash low financial model. There are two software used in this project, which are SolidWorks 2015x 64 Edition, and Arduino. The usage of tools will be discussed in the next sections. Most of the materials needed in the last stage, which is modelling and prototyping. The materials of the prototype needed include, electrical components, cardboard, and medium-density fiberboard (MDF).

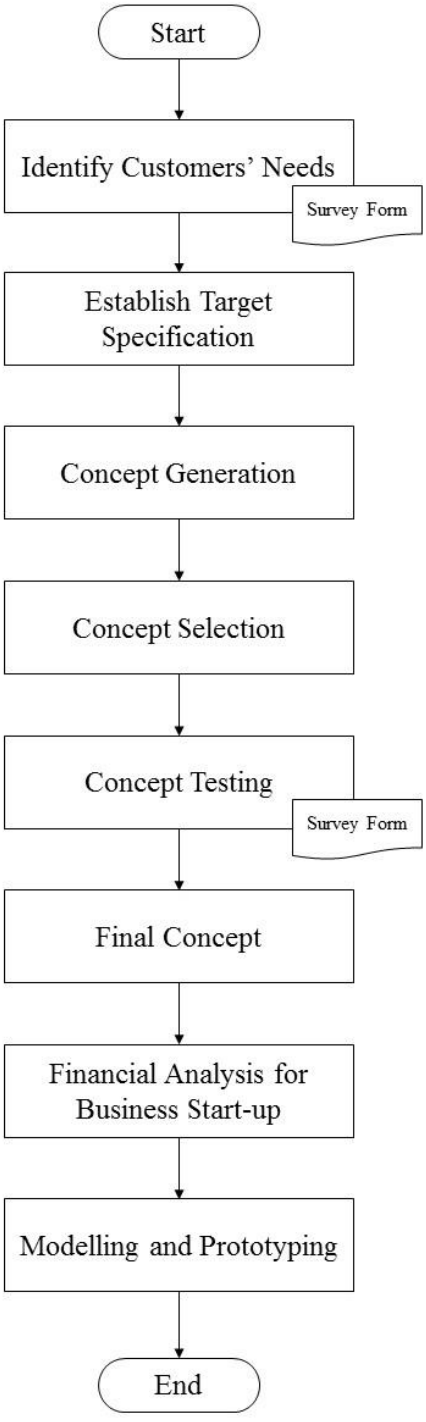

Figure 3.1 Flow Chart of Research (K.T. Ulrich 2012)

3.2 Identify Customers' Needs

Identifying customers' needs is a process, for which present in a five-steps method.

3.2.1 Step 1: Gather Raw Data from Customers

To create high-quality information channel directly from the customer, data gathering involves contact with customers. The method that used are:

1. Survey

   This survey is done through online by using Google Form. It is shared through social network to gather their opinions.
2. Observation in market

   Observation is done to look for opportunity of the product in the market.

3.2.2 Step 2: Interpret Raw Data in Terms of Customers' Needs

Customers' needs are expressed in written statements and results of interpreting the need underlying the raw data gathered from the customers. The needs are expressed in terms of what the product has to do as specifically as the raw data and the attribute of the product.

3.1.3 Step 3: Organize the Needs as Primary, and Secondary Needs

In this step, all the customers' needs are all organized into primary needs, secondary needs, and tertiary needs. Primary needs are the general needs, whereas secondary and tertiary needs are expresses the primary needs in more detail.

3.1.4 Step 4: Establish the Relative Importance of the Needs

A sense of relative importance of the various needs is essential to make these trade-offs correctly. The outcome of this step is a numerical importance weighting for a subset of the needs.

There are two basic approach tasks:

1. Relying on the consensus of the team members based on their experience with customer.
2. Basing the importance assessment on further customer surveys.

3.1.5 Step 5: Reflect on the Results and the Process

Throughout the process, the customers' needs are clearly identified. Thus, the criteria of the 2-in-1 automatic pet feeder is confirmed.

3.3 Establish Target Specification

After the process identifying the customer needs the preliminary specifications of the product are generated. These are the goal of the product which we believe will be able to compete in the market. These target specifications will be revisited and refined based on the limitations of the product concept selected. There are four steps in process of establishing the target specifications.

3.3.1 Step 1: Prepare the List of Metrics

The metrics is to reflect the degree to which the product satisfied the customer needs. Thus, the relationship of the needs and the metrics are studied. Translation of the customer needs to a measurable specification will ease the product concept generation as meeting the specification will thus achieve the customer needs also.

3.3.2 Step 2: Collect Competitive Benchmarking Information

To ensure the market value of the product, information of the specifications of the existing products is gathered. Therefore, the relationship of the new product to the competitive products is studied through the competitive benchmarking chart. Also, a small survey is done to know the customers' perception of satisfaction of needs towards the existing product and is documented into another form of competitive benchmarking chart.

3.3.3 Step 3: Set Ideal and Marginally Acceptable Target Values

In this step the target value for all the metric is set. There are 2 types of target values, marginal value and ideal Value. Marginal value is the value of metrics which the team feel that can make the product barely compete in the market, whereas the ideal value is the ideal and best result that wish to achieve.

3.3.4 Step 4: Reflect on the Results and the Process

Reflection helps to ensure that the results are consistent with the goals of the project. The target specification of the product is conducted.

3.4 Concept Generation

In order to place the product in a good market, an alternative design concept must be generated based on the customer needs and target specifications. An alternative product concepts of 2-in-1 automatic pet feeder is formed, which critical parts are taken into consideration so that the product can fulfil the customer needs. To achieve this, concept generation is clearly defined to ensure the product helps to solve problems that appeared in existing product.

A product concept is an approximate description of the technology, working principles, and form of the product. In addition, the degree to which a product satisfies the customers and can be commercialized depend on the quality of the underlying concept. Next, four concepts are generated for the automatic pet feeder. In this part, concept generation is the process that begins with a set of customer needs, and target specifications and result in a set of product concepts from which will make a final decision.

In order to generate an excellent concept that can be applied successfully to the product, the concept generation process is classified into several important steps.

3.4.1 Step 1: Clarify the Problem

This step can be easily processed as decomposing a complex problem into simpler sub-problems. This process is called problem decomposition so that the alternative solution can be generated for different discrete sub-problem easily.

3.4.2 Step 2: Search Externally

Few patents are searched to compare the specification of the product. Besides that, patents able to help to improve and invent the idea of the design.

3.4.3 Step 3: Search Internally

In the internal search, personal knowledge and creativity are to generate the solution concept. There are few methods used, which are make analogies, wish and wonder, use related stimuli, and use gallery method.

3.4.4 Step 4: Explore Systematically

After the external and internal search activities, some solutions are generated to each sub-problem. Then, the solution fragments are organized in morphology chart according to the parts.

3.4.5 Step 5: Reflect on the Solutions and the Process

Sub-function, advantages and disadvantages of the product are listed out in a table.

3.5 Concept Selection

Four concepts are developed in concept generation stage based on the target specifications considering the fulfillment of customer needs. Within these four concepts, their strengths and weaknesses are compared. During the process, some methods are used including the intuition, pros and cons, multi-voting, and decision matrices. There are two steps to select the final concept, which are concept screening and concept scoring.

In concept screening, one of the concept is made as a benchmark or reference. Thus, three concepts are chosen to undergo concept scoring. Concept scoring is used to differentiate among the competing concepts based on relative importance of the criteria. The customer needs are used as the selection criteria. Also, the importance weight to the matrix is added. In the last step, two out of three concepts are rated by using survey form to identify the potential market.

Results and process are reflected in concept selection, concept screening, and concept scoring. This is to determine the two concepts that chosen to undergo concept testing.

3.6 Concept Testing

The two concepts that are chosen in previous stage are undergoing concept testing. In this process, the customer response is assessed to these two concepts in order to decide which concept that can proceed with its development. Also, suggested improvements from the customers are gathered for the sake of modification of the selected concepts. This process is based on data gathered directly from the potential market. There are few methods for testing product concept.

3.6.1 Step 1: Define the Purpose of the Concept Testing

In concept testing, there are few questions that needed to be answered from the test, which are:

- To decide which development of concept can be proceeded.
- To understand the shortcoming of the concepts.
- To know any modifications that can be done on the concept.
- To understand whether customers' needs are fulfilled.

3.6.2 Step 2: Survey Population

In this step, primary and secondary market are listed and targeted.

3.6.3 Step 3: Survey Format

Online survey is prepared to get some feedback from the respondent. Besides that, an online platform is created in order to get more response for the design. Full description of the concept is posted so that the public able to rate the concepts. There are also some open questions to help the customers to understand the concepts so that they can make a wise choice.

3.7 Final Concept

The concept of product is finalized in final concept stage. The final specification of the product is also listed out parts by parts. In addition, a list of vendors is listed out. Each of the materials have 3 vendors to compare the prices. The vendors can be found through online, such as Lazada, 11 Street, Taobao, and Alibaba. Besides that, the materials and the estimated cost of the real product are listed out and calculated.

3.8 Financial Analysis for Business Start-up Purposes

There are three-step method for the economic analysis of a product development project.

3.8.1 Step 1: Build A Base-Case Financial Model

The base-case model consists of estimating the timing and magnitude of future cash flows and then computing the net present value (NPV) of those cash flows. There are 5 categories of cash flow for the project, which are development cost, ramp-up cost, marketing and support cost, production cost and sales revenue. All these categories of cash flow are estimated. An NPV of the cash flow is computed.

3.8.2 Step 2: Perform Sensitivity Analysis

In this step, the financial model is used to calculate the NPV corresponding to a change in both of internal and external factors. The financial model is performed by using 20% decrease in development cost and 25% increase in development time.

3.8.3 Step 3: Use Sensitivity Analysis to Understand Project Trade-Offs

The financial model is recalculated by using 10% increase in sales volume.

3.9 Modelling and Prototyping Development

Modelling and prototyping is the last stage of the project. A prototype is built to test and show the functionality of the product. The materials of the prototype are different from the materials for the real product. The materials of prototype include, cardboard and medium-density fiberboard (MDF). However, for the electrical components include, Arduino Mega R3, servo motor, stepper motor, water level sensor, and LCD display. In real product, the microcontroller used is raspberry pie as it has a better specification compared to that of Arduino Mega R3. After the prototype is built, a demonstration is conducted to test the functionality of the product.

3.9.1 Fabrication Process for Mechanical Parts

A suitable material is chosen to build the prototype of the design. Medium-density Fiberboard (MDF) is used to build the base structure of the pet feeder. While, cardboards are used to build the body of the feeder. Next, the boards are cut into sizes according to the dimension in SolidWorks. Surface finishing is a must to improve the appearance of the product. Epoxy is applied on the surface of the MDF and cardboard to combine and build a proper structure. Holes are drilled on the MDF to allow the jumper wires connect to the components. Before functionality test, all the boards and components are assembled. Figure 3.2 shows the fabrication process for mechanical parts.

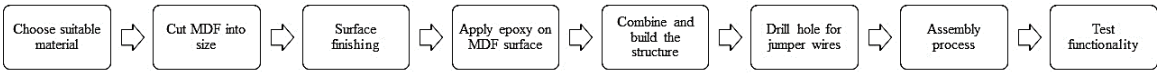

Figure 3.2 Fabrication Process of Mechanical Parts

3.9.2 Fabrication Process for Electronic Parts

Arduino is chosen as the microcontroller for the prototype of the product. This is because Arduino is a ready-to-use structure. It is also a basic single board microcontroller designed for many applications. The components used in the prototype are servo motor, LED, water level sensor, stepper motor, driver, Arduino board, LCD display, breadboards, and batteries. All the components are connected to the Arduino board. Two Arduino programs are developed for food mechanism and water mechanism. In the last step, all the programs are combined and the test is run. Figure 3.3 shows the fabrication process of electronic parts.

Figure 3.4 and Figure 3.5 shows the connection and schematic diagram of the LCD display and real-time clock. This is to display the current time and the feeding time. Figure 3.6 and Figure 3.7 shows the connection and schematic diagram of stepper motor and driver. Driver is used to drive stepper motor, so that the food is able to be released. Food mechanism involves LCD display, real-time clock, potentiometer, stepper motor, LED, and driver. Figure 3.8 and Figure 3.9 shows the connection and schematic diagram of the water mechanism. In water mechanism involves servo motor, LED, and water level sensor. Refer

to Appendix U and Appendix V for Arduino program for food and water mechanism respectively.

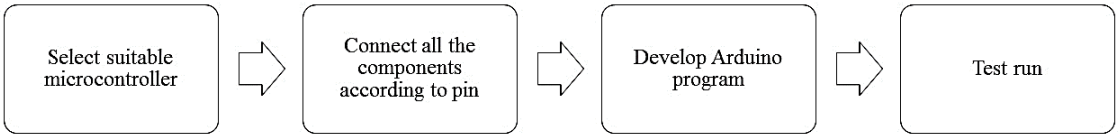

Figure 3.3 Fabrication Process of Electronic Parts

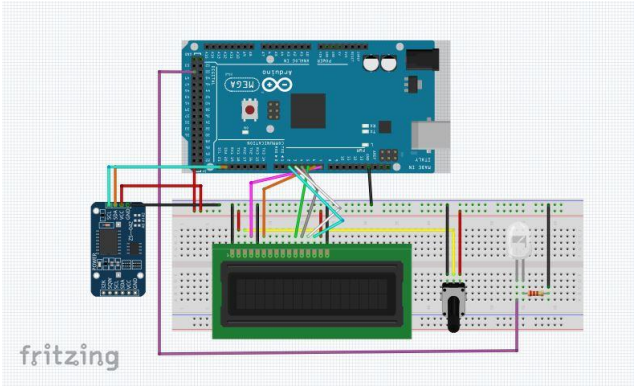

Figure 3.4 Connection of LCD Display and Real-time Clock

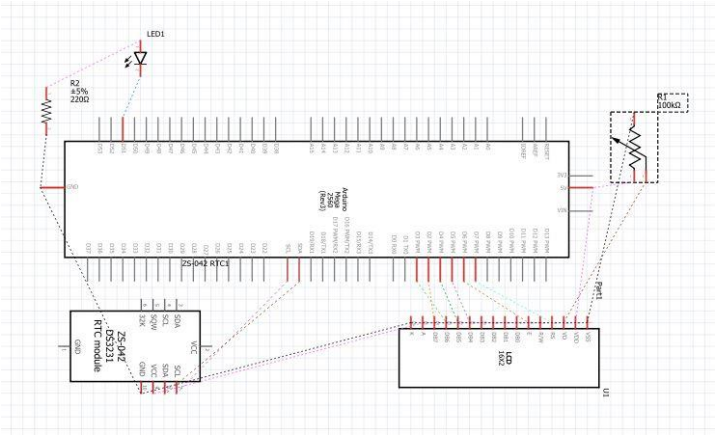

Figure 3.5 Schematic Diagram of LCD Display and Real-time Clock

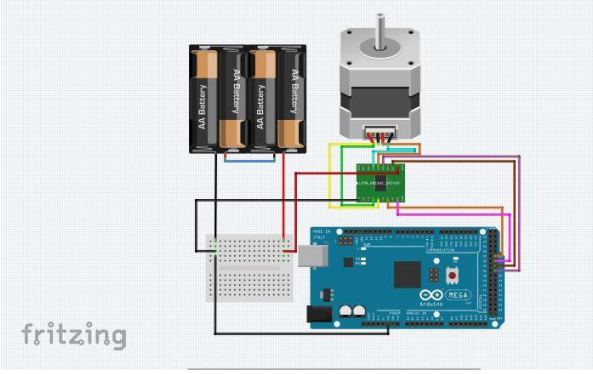

Figure 3.6 Connection of Stepper Motor and Driver

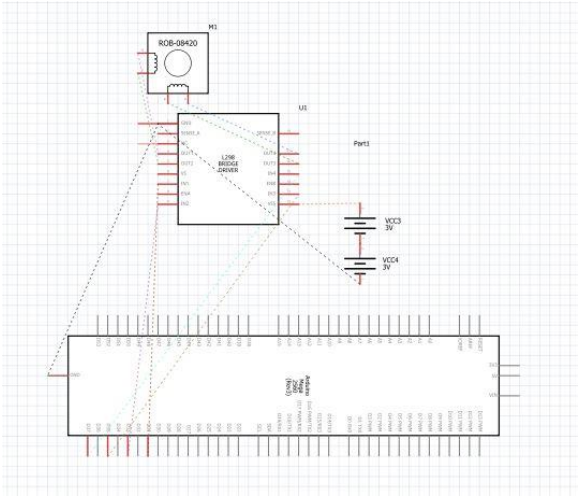

Figure 3.7 Schematic Diagram of Stepper Motor and Driver

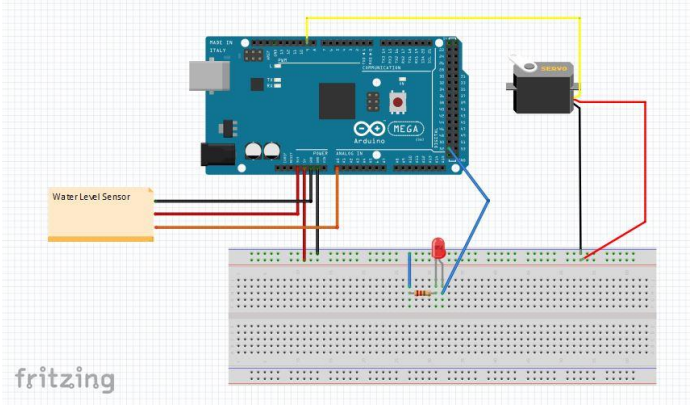

Figure 3.8 Connection of Water Mechanism

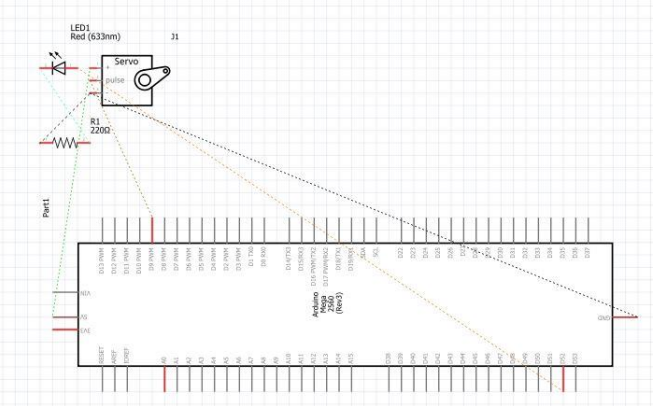

Figure 3.9 Schematic Diagram of Water Mechanism

3.10 Survey

There are two different survey forms in this research, which are customers' needs identifying survey and concept testing survey.

3.10.1 Customers' Needs Identifying Survey

Frequency of going on vacation is to survey how frequent are the people going to travel. This is because most of the people who keeps pets at home would tend to forget and they got no time to feed their pets when they go on a vacation. Question three and question four are to collect the data of pet ownership and number of pets owned.

In question five, it is to see how often the pet owners feed their pets. This is because every pet owner has different feeding time as the best frequency of feeding the pets is twice per day (Petfinder 2017). There are three ways to feed pets, which are free feeding, portion-controlled feeding and schedules feeding (petMD 2017). Therefore, question six is to collect the data of the methods of the pet owners feed their pets.

Pet feeder is the assistance of the pet owners. In question seven, the result is to reflect the number of respondents owns a pet feeder at home. This is to target the market of the pet feeder. Besides that, pet feeder helps to control and manage the dietary of pets. In question eight, the data collected reflects the importance of pets' dietary. This is because pet obesity puts the pets at higher risk for heart disease, diabetes, and joint problems. Criteria of a product is important to create and modify an existing product. Therefore,

question nine is to collect the data of the relative importance of characteristic of pet feeder. This is to create the specification of the pet feeder. See Appendix A for sample of survey questions and forms.

3.10.2 Concept Testing Survey

Concept testing survey is to get some feedback from the respondent for the designs. In the first question, preferable concept is asked to decide which concept can be proceeded. Question two is to understand whether the concept fulfils the customers' needs. In question three, the result reflects that any further modification and shortcomings for the concept. Question four is to compare the probability of respondents buying the product if it is launched in the market. See Appendix D for sample of survey questions and forms.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Identify Customers' Needs

Identifying customers' needs is a process, for which present in a five-steps method.

4.1.1 Gather Raw Data from Customers

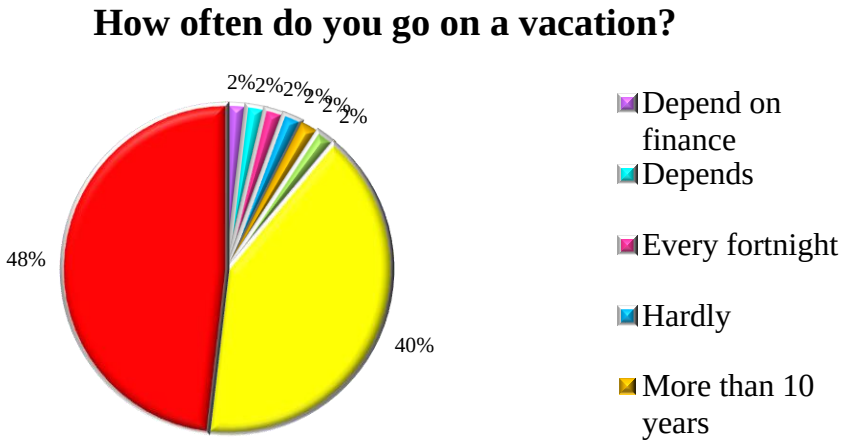

Figure 4.1: Frequency of Going on Vacation

From Figure 4.1, there are 48 percent of respondents travel once per year, whereas 40 percent of respondents travel once in a 6-month.

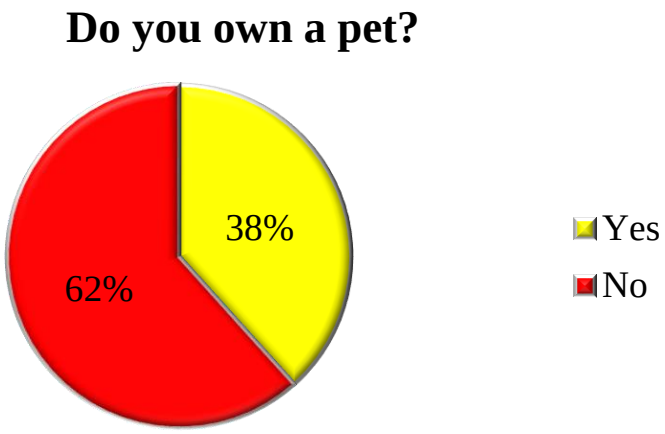

Figure 4.2 Pet Ownership

Based on Figure 4.2, there are 38 percent of respondents own a pet, whereas 62 percent of respondents do not own a pet.

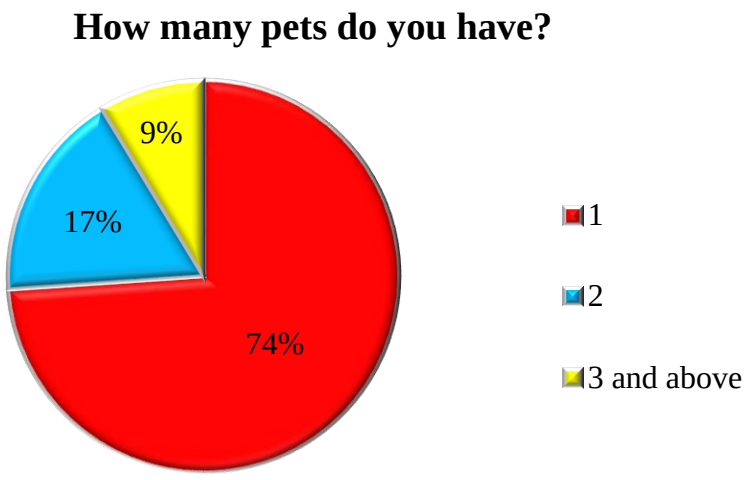

Figure 4.3 Number of Pets Owned

According to Figure 4.3, there are total of 23 out of 60 respondents own a pet. From the chart, there are 74 percent of respondents own only one pet, 17 percent of respondents with two pets and 9 percent own more than three pets.

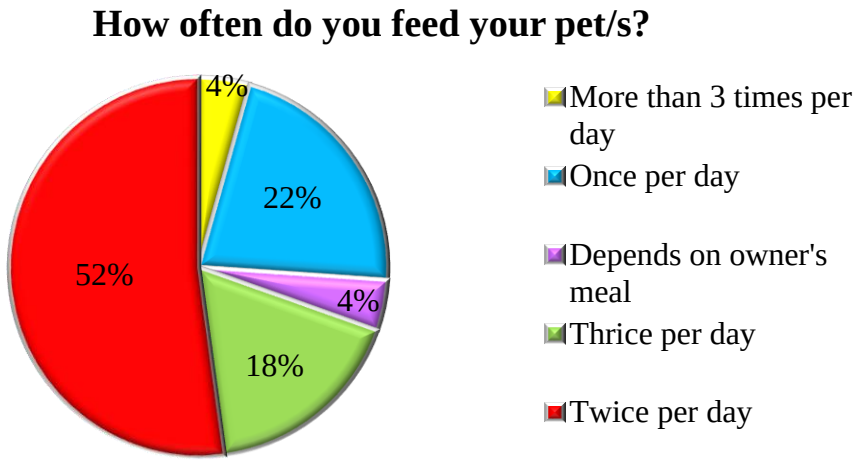

Figure 4.4 Frequency of Pet Feeding

From Figure 4.4, most of the respondents feed their pets twice a day, which is 52 percent of the respondents. There are pet owners who feed their pets once per day and thrice per day, which are 22 percent and 18 percent respectively. There are 4 percent of respondents feed their pets more than three times per day. The other 4 percent of respondents feed their pets when they are having their meal at the same time.

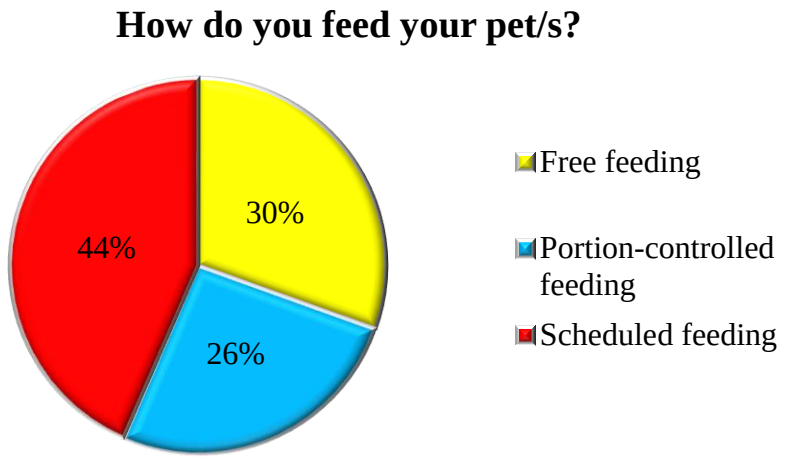

Figure 4.5 Methods of Pet Feeding

Figure 4.5 shows that 44 percent of respondents feed their pets according to the schedule, whereas 30 percent of respondents feed their pets freely. The other 26 percent of the respondents feeds their pets with portion-controlled.

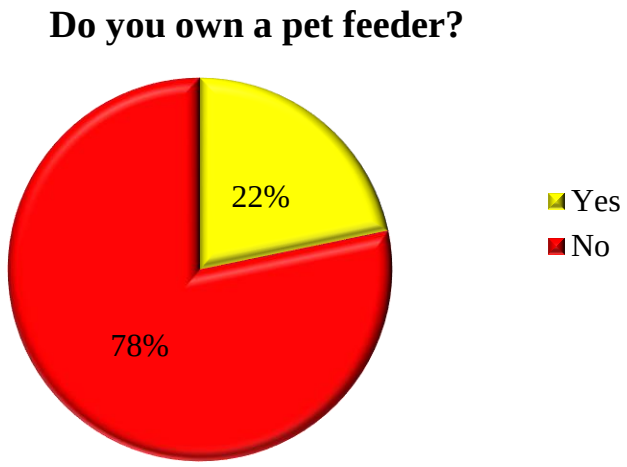

Figure 4.6 Pet Feeder Ownership

Based on Figure 4.6, 18 out of 23 of respondents do not own a pet feeder, whereas there are only 5 out of 23 respondents own a pet feeder.

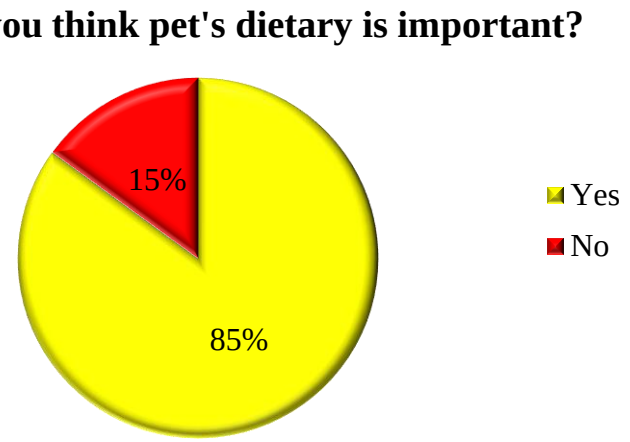

Figure 4.7 Importance of Pet's Dietary

Figure 4.7 shows that 85 percent of respondents agree with the importance of pet's dietary, whereas there are 15 percent of respondents do not agree.

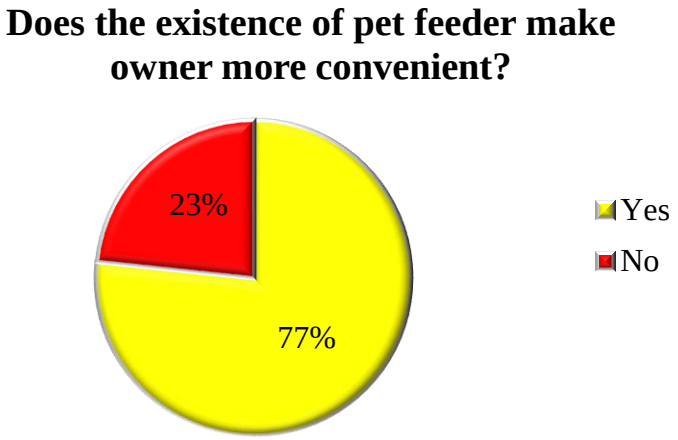

Figure 4.8 Convenience of Existing Pet Feeder

According to Figure 4.8, most of the respondents, which is 77 percent are agree with the existence of pet feeder makes owner more convenient. It helps the owner to feed their pets even when the owner is too busy to feed them.