THE FEASIBILITY OF TRIZ BENCHMARKING TOOL AS A DECISION-MAKING ALGORITHM

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DECLARATION

I declare that this report entitled “THE FEASIBILITY OF TRIZ BENCHMARKING TOOL AS A DECISION-MAKING ALGORITHM” is the result of my own work except for quotes as cited in the references.

Signature :

Author : Nur Syamilah binti Mohd Yazid

Date : 13/6/2021

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : .....

Supervisor Name : Ts. Dr. Mai Mariam Mohamed Aminuddin

Date : 25 Jun 2021

DEDICATION

All praise and thanks to Allah for everything I have done in creating an opportunity and guidance. This research is contributed unreservedly to my deepest appreciation, who were my parents. The source of inspiration and considerable moral, spiritual, and convolution kernel of love and relational love. Finally, to my siblings, relatives, and classmates, who are always helping me to complete this study and just be there for me throughout all times.

ABSTRACT

Making a decision involves many data and classifications that are difficult to be obtained, it needs a special problem-solving method algorithm to solve it. Benchmarking method and the Fuzzy method are the problem-solving methods that could be used to solved complicated problems. The main focus of this study is to prove that the feasibility of the TRIZ benchmarking tool as a decision-making algorithm. The methodology of this study includes the use of Microsoft Excel, Google form, and Matlab software. Microsoft Excel is used to perform calculations, Google Form is used to collect responses towards this study and Matlab software is used to develop Graphical User Interfaces (GUIs). The surveys are focused on the UTeM students. This survey was distributed by using Google Form as the platform to analyze these two methods based on respondents' satisfaction. The survey also shows how the methods work for the respondents. Around 90 students respond to the survey and 85 of them satisfy with the Benchmarking method as a problem-solving method. As a result, GUIs were developed for the benchmarking methods as it is chosen to be a decision algorithm.

ABSTRAK

Untuk membuat keputusan melibatkan banyak data dan klasifikasi sukar diperoleh. Ia memerlukan algoritma kaedah penyelesaian masalah khas untuk menyelesaikannya. Kaedah penanda aras dan kaedah Fuzzy adalah kaedah penyelesaian masalah yang dapat digunakan untuk menyelesaikan masalah rumit. Fokus utama kajian ini adalah untuk membuktikan bahawa kelayakan alat penanda aras TRIZ sebagai algoritma pembuatan keputusan. Metodologi kajian ini merangkumi penggunaan perisian Microsoft Excel, Google form, dan Matlab. Microsoft Excel digunakan untuk melakukan pengiraan, Google Form digunakan untuk mengumpulkan respons terhadap kajian ini dan perisian Matlab digunakan untuk mengembangkan Interface Pengguna Grafik (GUI). Tinjauan ini tertumpu kepada pelajar UTeM. Tinjauan ini diedarkan dengan menggunakan Google Form sebagai platform untuk menganalisis dua kaedah ini berdasarkan kepuasan responden. Tinjauan juga menunjukkan bagaimana kaedah berfungsi untuk responden. Kira-kira 90 pelajar menjawab tinjauan dan 85 daripadanya berpuas hati dengan kaedah Penanda Aras sebagai kaedah penyelesaian masalah. Konklusinya, GUI dikembangkan untuk kaedah penanda aras kerana dipilih untuk menjadi algoritma keputusan.

ACKNOWLEDGEMENTS

First and foremost, all praises for the blessings and encouragement that render Allah S.W.T. for the output of this research is possible.

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LIST OF SYMBOLS AND ABBREVIATIONS

BOA	-	Bisector of Area
CMCO	-	Conditional Movement Control Order
COA	-	Center of Area
COG	-	Center of Gravity
COS	-	Center of Sums Method
FLC	-	Fuzzy Logic Controller
FOM	-	First of Maxima
GUIs	-	Graphical User Interfaces
IoT	-	Internet of Thing
Max	-	Maximum
MCO	-	Managed Care Organizations
Min	-	Minimum
ODL	-	Online Distance Learning
PC	-	Project Contributions
PO	-	Project Objectives
SUV	-	Sport Utility Vehicle

TRIZ	-	Theory of Inventive Problem Solving
USSR	-	Union of Soviet Socialist Republics
WFH	-	Work from Home

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Motivation

For processes that do not accept a mathematical model or where the data is imprecise, Fuzzy Logic is used in control system design. Fuzzy Logic controllers are fuzzy expert systems that could model a process for the human operator. The linguistic description of the variables of the process is based on it. First of all, this study presents the basic notions of fuzzy sets and fuzzy logic. They define fuzzy sets and fuzzy operations. In addition, the concepts of linguistic variables, linguistic variables, term set, fuzzy rule bases, inference methods, defuzzification methods are important to understand for the control system. Next, this paper introduces the procedure for the design of a basic step fuzzy logic control system. Ten examples showing the capabilities of fuzzy logic control systems illustrate the design procedure.

In this study, TRIZ, a systematic problem-solving methodology, is proposed to close the gaps to overcome the restrictions in service design tools and idea generation practices. TRIZ was first developed in the former USSR, starting in 1946, by Genrich Altshuller and his colleagues. A TRIZ tool for problem-solving is benchmarking. An analysis will be carried out in this paper to differentiate between fuzzy methods and methods of benchmarking for problem-solving instruments. These two techniques will be used to compare the best consumer-based approaches to problem-solving. The fuzzy method the method that will be used the minimum of the characteristics that the consumer wants. In this analysis, it will be shown that benchmarking method could improve the fuzzy control system

1.2 Problem Statement

Fuzzy is used throughout our everyday lives. In various applications, such as facial pattern recognition, air conditioners, washing machines, vacuum cleaners, and anti-skid braking systems, Fuzzy logic has been used. For a multiple and complicated problem in the form of decision making and use, the ability of fuzzy to solve grey is helpful. Fuzzy logic, however, is not always precise, the results are perceived based on assumption, and some fuzzy time logic is confused with the theory of probability and the terms, it may not provide precise reasoning, but the only acceptable reasoning. The table shows the advantage and disadvantages of using fuzzy logic.

Advantages of Fuzzy Logic	Disadvantages of Fuzzy Logic
• The Fuzzy Logic System's structure is easy and understandable. • For commercial and practical purposes, fuzzy logic is used widely. • It helps you to control consumer products and machines. • It may not offer accurate reasoning, but the only reasoning that is acceptable. • It allows you to address the uncertainty in engineering. • Mostly robust, since no specific inputs are needed. • In a situation where the feedback sensor stops working, it can be programmed. • It can be easily modified to improve or alter the performance of the system.	• Fuzzy logic is not always accurate, so based on assumption, the results are perceived, so it may not be widely accepted. • As well as neural network type pattern recognition, a fuzzy system does not have the capability of machine learning. • Validation and verification of a fuzzy system based on knowledge require extensive hardware testing. • Setting precise, fuzzy rules and functions for membership is a tough task. • Some fuzzy time logic is mistaken for the theory of probability and terms.

Table 1.2.1 Advantages and Disadvantages of Fuzzy Logic [1]

Therefore, fuzzy logic is not providing a reliable and optimum result. TRIZ benchmarking is a problem-solving tool for an innovative problem. It is used to find main parameter values for a new system from multiple available systems. Based on these criteria, there is a chance that TRIZ benchmarking could be used as a tool for decision-making. For optimum and reliable results, a model based on benchmarking needs to be developed.

Using a more precise procedure or model that can be used as a tool in the selection process, this problem can be overcome and that ensures a true final result. The fuzzy logic model provided in this paper enables the consumer to identify

expectations and concerns when ranking competing companies and to achieve better (or anticipated) results in this way.

1.3 Objectives

The aims for this thesis are laid out in Project Objective (PO). The aims of the thesis are explained as follows;

- To develop a benchmarking model for a decision-making tool.

- To analyze the feasibility of the benchmarking model in deciding the optimum decision result differentiate by benchmarking and fuzzy.

1.4 Project Scope

In this project, Benchmarking and Fuzzy Logic methods will be used for decision-making. This analysis is to build an application to choose the car. The difference between these methods will be implemented by using the survey by using the Google form. This survey will be distributed to 90 respondents.

This project will also run by using software because the current issue of Covid-19 limited the students to perform their lab work. This analysis will be including some calculations and statistics majorly by using Excel Software as the alternatives. It may come out with applications and easier for students to make decisions.

1.5 Project Contribution

The output of this project (PC) is to develop a benchmarking model for a decision-making tool. The selected features combined with computer learning elements will help to analyze the feasibility of the benchmarking model in deciding the optimum decision result differentiate by benchmarking and fuzzy. TRIZ benchmarking is a problem-solving tool for an innovative problem. It is used to find main parameter

values for a new system from multiple available systems. Based on these criteria, there is a chance that TRIZ benchmarking could be used as a tool for decision-making.

The summary of this project contribution is shown below;

I. Identification of various types of cars and make data collections.

II. Propose a solution that can detect the best decision accurately.

III. For optimum and reliable results, a model based on benchmarking needs to be developed.

1.6 Thesis Organization

This study consists of five chapters: Chapter 1: Introduction, Chapter 2: Analysis of Literature, Chapter 3: Methodology of the Project, Chapter 4: Result and discussion, and Chapter 5: Conclusion and future work.

1.6.1 Chapter 1: Introduction

This study consists of five chapters: Chapter 1: Introduction, Chapter 2: Analysis of Literature, Chapter 3: Methodology of the Project, Chapter 4: Result and discussion, and Chapter 5: Conclusion and future work.

1.6.2 Chapter 2: Literature Review

This chapter covers the previous researcher's similar experiments that were later examined to find the difference between them, thus becoming the outputs of this project.

1.6.3 Chapter 3: Project Methodology

The purpose of Chapter 3 was to create a rigid collection of works that had to be completed to achieve the previously stated goals. The approach comprises the steps and processes in this project in every practicable manner.

1.6.4 Chapter 4: Analysis and Design

Analysis and design-based procedures related to the sequence of experiments in this chapter. First, the experiments evaluate their affectivity by responding to the literature and then are carefully structured to accomplish their respective objectives.

1.6.5 Chapter 5: Implementation

This core chapter is where all discussed procedures in the previous chapters are been carried out. It will describe in detail each step involved and the environmental setup for the experiments.

1.6.6 Chapter 6: Discussion

This chapter discusses the results and analyzes them to show whether the objectives were answered.

1.6.7 Chapter 7: Overall Conclusion

This chapter outlines the initiative, notes the contribution, and illustrates the project-wide restrictions. To further develop the project, this chapter will also detail what should be done next in the future.

1.7 Conclusion

This research is conducted to evaluate the best decision-making methods based on the minimum and the maximum values given by the respondents. The fuzzy logic model that is presented in this paper allows the user to define preferences and concerns when ranking competing firms and in this way obtains better (or expected) results. The model has then tested its accuracy and compared with other technique. This paper also is to analyzes the feasibility of the benchmarking model in deciding the optimum decision result differentiate by benchmarking and fuzzy. The next chapter will discuss in detail the related works/literature based on the Fuzzy Logic Boolean expression and benchmarking as the problem solutions tools.

CHAPTER 2

BACKGROUND STUDY

2.1 Introduction

This chapter aims to discuss the related works regarding the applications that are used on these two methods. The literature defined fuzzy logic in-depth, the TRIZ benchmark, and referred to several checked sources. It will serve as a critical overview of published research related to the subject. This will provide a good overview of what has just been done, what is generally known, what is evolving, and what the current state of thought on the subject is. More specifically, this literature will lead to a deeper understanding of the issue of research being studied.

2.2 Overview of Fuzzy Logic

Fuzzy logic differs in that statements are no longer black or white, true or false, on or off, from classical logic. An object takes on a value of either zero or

one, in traditional logic. A statement can assume any real value between 0 and 1 in fuzzy logic, representing the degree to which an element belongs to a particular set. [2] In Fuzzy logic and fuzzy systems, the elements that have degrees of membership in the set are fuzzy sets. An expansion of the classical set is Fuzzy sets. [3]

In the decision-making process, fuzzy sets are a very useful tool to elaborate on the concept of uncertainty. This study analyzes the theory of Fuzzy sets in this study and applies the theory to solve problems in real-world decision-making. By defining the value of the characteristic, this study also solves the problem and also modifies our algorithm by assigning capping values to each parameter, then calculating the value of the capping choice. [4]

Nevertheless, in normal probability, fuzzy sets use a minimum of (MIN). The similarity is equal to MIN. The data that is similar to every preference is therefore 0.0. For instance, if the distance is moved from the list, it changes the value of the smallest of all preferences.

Figure 1.6.7-1 The example data using fuzzy sets [3]

When defining a fuzzy model, there are three main tasks to be considered:

i. Choice of a suitable family of parameterized membership functions.

ii. Interviewing human experts who are familiar with the target system to determine the membership function parameters used in the rule base.

iii. Using regression and optimization techniques, refining the parameters of membership functions.

Using only the first task and partly the second, the fuzzy models presented in this paper were developed.

The three components that comprise the model are:

- Selected descriptors of the firm (parameters)
- Vocabulary set by Fuzzy
- Each variable's domain [5]

2.2.1 The Operation of the Fuzzy Logic Controller

Fuzzy information is one thing to compute, reason, and model with fuzzy data; another is to apply the fuzzy results to the world around us. Although the bulk of the information assimilated every day is fuzzy, the majority of human or machine-implemented actions or decisions are crisp or binary. [6] Fuzzy logic controller operations, including fuzzification and defuzzification.

The Steps performed by the Fuzzy logic controller are:

i. Fuzzification:

To obtain the membership values of each linguistic label, the input variables are compared with the membership functions on the anterior part of the fuzzy rule.

ii. Inference Engine:

To get firing strength, i.e. degree of fulfillment of each rule, combine the membership values by using multiplication or min function on the premise part.

iii. Inference Engine:

Generates the qualified consequences that, depending on the firing strength, can be either fuzzy or crisp on each rule.

iv. Defuzzification:

Here, to produce crisp output, the qualified consequences are aggregated. In the given diagram, each stage of the fuzzy expert system is represented with the following description of each term:

1. Input: The Crisp values that are assigned to the decision-making system.

2. Fuzzification: With the help of the membership function, crisp inputs from the domain are transformed into fuzzy inputs in this process.

3. Inference Engine: For mapping inputs to outputs, it uses rules. For the conclusion portion of each rule, the appropriate rule is applied. This results in the assignment of one fuzzy subset to each output variable for each rule.

4. Defuzzification: It is a process of transposing the fuzzy outputs from the given fuzzy sets and corresponding degrees of membership to crisp outputs.

5. Knowledge Base: Repository of rules to find a degree of membership that is applied to fuzzy sets

6. Output: The final crisp value offered by the system as a decision.

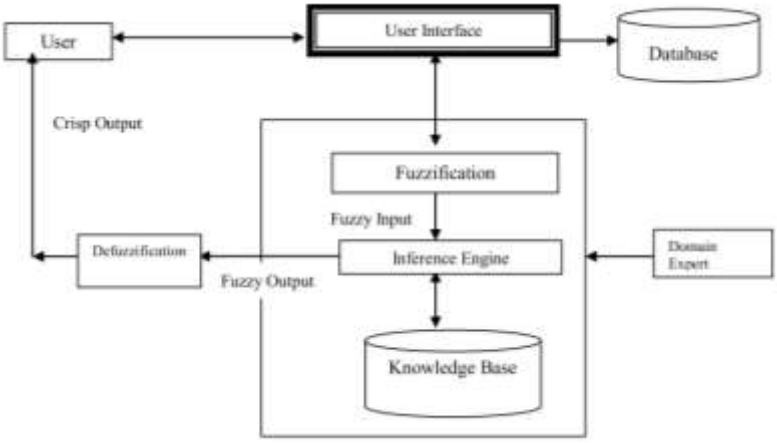

Figure 2.2.1-1 the Stages of the Fuzzy Logic Controller System

[7]

2.2.1.1 The Fuzzification

Fuzzification is the process of transforming crisp inputs from the domain into fuzzy inputs with the assistance of the membership function. [7] The core of the fuzzy engine is formed by fuzzification components. Whenever the sensors report the temperature and fan velocity values, they are mapped to the respective fuzzy regions they belong to base on their membership. [3] Hardware such as a digital voltmeter generates crisp data in the real world, but such data is subject to experimental errors.

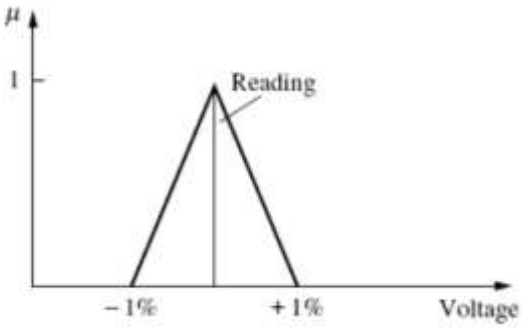

Figure 2.2.1-2 The membership function representing the imprecision in "crisp voltage reading."

When such data is used in fuzzy systems, the representation of imprecise data as fuzzy sets is a useful but not mandatory step. When such data is used in fuzzy systems, the representation of imprecise data as fuzzy sets is a useful but not mandatory step. This idea is shown in Figure 2.2.1-3 a, where the data considered as a crisp reading, Figure 2.2.1-3 b, or as a fuzzy reading, as shown in Figure 2.2.1-3 below:

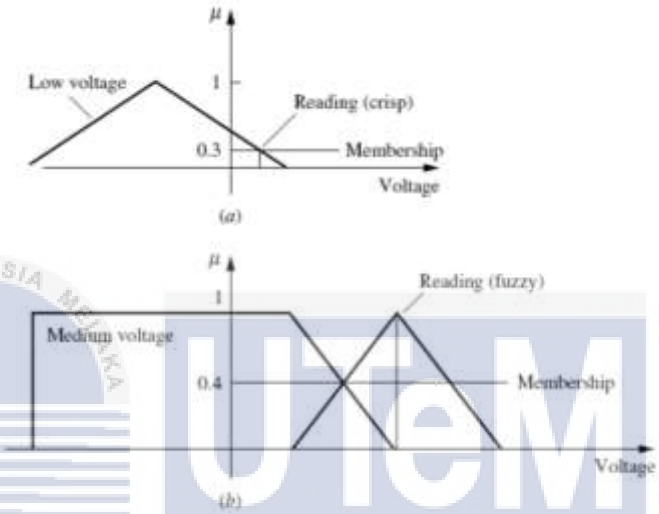

Figure 2.2.1-3 (a) fuzzy set and crisp reading; (b) fuzzy set and fuzzy reading

Comparing fuzzy sets and the crispness of fuzzy readings is shown in Figure 2.2.1-3 (a) fuzzy set and crisp reading; (b) fuzzy set and fuzzy reading [6]

2.2.1.2 The Defuzzification

When an output fuzzy set is mapped to a crisp value, the defuzzification process is present in a fuzzy system. Features are provided that are the basis for a comparison of the defuzzification techniques. [8]

The known methods of defuzzification are the following:

i. Core of the System for Sums (COS)

ii. The system of the center of gravity (COG) / Centroid of Area (COA)

iii. The Core of Region / The Area Bisector System (BOA)

iv. Method of Average Weighted

v. Methods of Maxima

- The First Method of Maxima (FOM)
- Last of Method Maxima (LOM)
- Mean of Process Maxima (MOM) [9]

Defuzzification techniques can be formulated in a discrete (using Σ) or continuous (using ∫) form in the general case. The only discrete form is considered in the document for the sake of simplicity. The basic techniques are discussed with the characteristics given in Section 3 in mind for each class of techniques. [8]

In this research paper, the main focus is on Maxima Methods and Center of gravity (COG) / Centroid of Area (COA) Method:

i. Maxima Methods

In this analysis, Maxima or Maxima techniques will be used. The maximum method gives an element from a fuzzy set core as a result of defuzzification. A fuzzy set core (designated as a core) consists of elements of a discourse universe defined by that set with the highest degree of membership in the fuzzy set. The first-of-maxima technique, FOM, can be considered as the basic representative of that group, provided by the expression (3):

$$y0=mincore(B')=fom(B')$$

For general fuzzy expert systems, those methods are convenient. Computationally efficient, they are: what they require is about $2\cdot N_q$ simple operations. Maxima techniques belong to the group of the fastest methods of defuzzification because they only require passing through the core values.

There are also the following maximum techniques according to the element with the maximum membership that is extracted as the result of defuzzification: middle-of-maxima, MOM, last-of-maxima, LOM, and random-choice-of-maxima, RCOM. The techniques are compatible with the maximum operation. [8]

ii. Center of gravity (COG) / Centroid of Area (COA) Method

This method provides a crisp value based on the fuzzy set's center of gravity. The total area of the distribution of the membership function used to represent the combined control action is broken down into several sub-areas. The area and the center of gravity or centroid of each sub-area are calculated and then the summation of all these sub-areas is taken to find the defuzzified value for a discrete fuzzy set. [9]

2.3 Overview of Benchmarking

Benchmarking is the instrument that turns the unstructured process of constant improvement into an objective plan of action. When problems are identified, benchmarking starts and focuses on detecting kernel issues to enhance current practice. There are several techniques available for this investigation that partially complement each other and or are based on each other. The choice of a method is mainly determined by the objective of increasing the added value. For benchmarking, it is important to understand that before expensive resources are invested, these benefits are to be expected. (Mertins et al., 1995)

2.3.1 The Operation of the Benchmarking Controller

There are two basic types of comparison when you think about benchmarking: internal and external benchmarking. (HotStats, 2019) There are two kinds of benchmarking, discussed as described in:

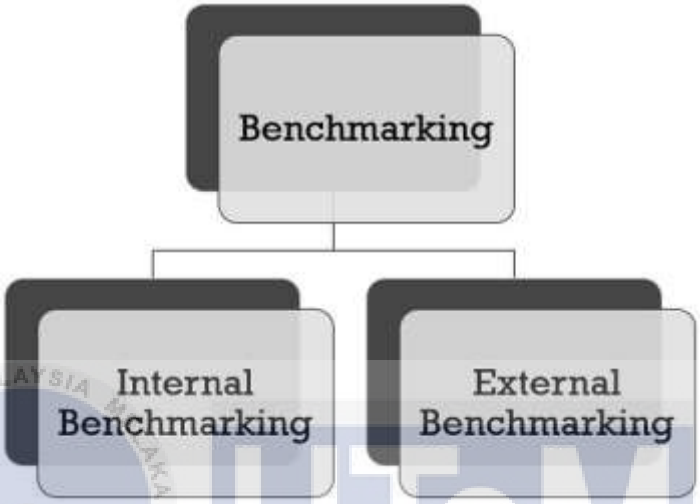

Figure 2.3.1-1 Two types of benchmarking

Internal Benchmarking: The benchmarking is said to be internal when measuring and comparing key activities between teams, groups, and individuals are made within the organization.

External Benchmarking: When key operations are measured and compared with competitors, it is called external benchmarking. (Marketing et al., n.d.)

2.3.1.1 External Benchmarking Methods

Internal Benchmarking is the easiest method of benchmarking since it is not required to take into consideration any external limits. Organizations aim to learn from their divisions, agencies, and sister companies by internal benchmarking. Similar processes are examined and compared across different areas during these studies to

obtain detailed information about the performance potential provided. It is easy to implement and access data, but the success of a performance-increasing change is low because units that belong together tend to comply with cultural and organizational standards. In internal benchmarking, the management's look is turned inward before it is turned outward. Current sequences and practices of operation shall be recorded objectively and understood. This way, the necessary details are obtained to focus the study on the elements. (Mertins et al., 1995)

2.3.1.2 Internal Benchmarking Methods

Benchmarking is a tool for looking outside where the company's operations are relative to the external practices. Comparison implies that a basic line of similarities must be present. It is only possible to compare similar things to each other. Therefore, one's operations and processes need to be recognized. Only then can a valid comparison and the detection of potential for change be made possible. The ideal case is that such a study could include many enterprises,

i. to minimize the costs,

ii. for easier data collection,

iii. the results can be used on a broad basis. (Mertins et al., 1995)

2.4 Previous works

The main objective of this section is to demonstrate awareness of the current state of knowledge relating to this research topic (theoretical, methodological, applied).

2.4.1 Fuzzy Logic as AI tools

Various approaches to feature selection techniques are available and studied among researchers. A. Chandramohan and M. V. C. Rao (2006) proposed the issues of obtaining new definitions for hedges that exceed the traditional definitions given by Zadeh (and others), particularly seeing that the effect of applying these hedges does not cross beyond the reasonable limits of membership values [0,1] and is still meaningful from the point of view of the magnitude of membership value and hence be effective for an application. In the very common case of knowledge-based systems in which vague concepts and imprecise data must be handled, fuzzy logic provides a useful tool that presents the interest of allowing to manage both imprecision and uncertainty. In this framework, linguistic modifiers are more important issues in the treatment of data through fuzzy logic. These modifiers play the same role in fuzzy modeling as adverbs and adjectives do in language: they both modify qualitative statements. [10]

Hemlata Aggarwal, H.D. Arora, Vijay Kumar (2019) states that the theory of Fuzzy sets and applies this theory to solve real-world decision-making problems. They solve the problem by defining the choice value and also modify our algorithm by assigning weight to each parameter and then calculate the weighted choice value. In real-life problems, the class of objects does not have well-defined criteria of membership that is confusion about the inclusion or exclusion of objects in the class. This is the reason for uncertainty in decision-making problems. This uncertainty arises due to a lack of knowledge about the inclusion and exclusion of objects in a particular class or due to inherent vagueness. These types of problems can be solved by existing mathematical theories such as the theory of probability, theory of fuzzy sets, the theory of Intuitionistic fuzzy sets, the theory of vague sets, the theory of Rough sets, etc.

Many researchers have worked on applications of fuzzy sets in decision-making problems. Coroiu presented the advantages of the fuzzy approach, in comparison with another paradigm, and presents a particular way in which fuzzy logic can emerge in the decision-making process. Han xiao and Chen Shou presented an application of fuzzy sets in the reallocation of replaced water of the yellow river. Chiu-Chi Wei presented a potential project selection model, which combines optimal aggregation method and effective fuzzy weighted average to assist decision-maker to achieve the best consistency of fuzzy judgments, and generates a single synergistic index project fuzzy synthetic rating that considers both risk and performance. Chanqiou tan discussed a new method for solving multi-criteria decision-making problems in interval-valued intuitionistic fuzzy environments in this paper we present an application of fuzzy sets in a decision-making problem with the help of choice value and weighted choice value of a fuzzy set. Now, we present the basic definitions of fuzzy sets introduced by Zadeh and some related concepts. [4]

Krishna Gogoi, Alock Kr. Dutta, Chandra Chutia (2014) states that in our daily life we often face some problems in which the right decision making is highly essential. But in most of these cases, we become confused about the right solution. To obtain the best feasible solution to these problems we have to consider various parameters relating to the solution. For this, we can use the best mathematical tool called Fuzzy soft set theory. In this paper, we select a burning problem for the parents and successfully applied the Fuzzy soft set theory in decision making. [11]

Shaily Thaker, Viral Nagori (2018) states that guidelines useful for developing the fuzzification method are derived based on the analysis. The choice of the

membership function is found to be a component of the fuzzification process, which plays an important role in the success of the Fuzzy Expert system. [7]

Author	Title	Result/Description
A. Chandramohan, M. V. C. Rao	The novel, Useful, and Effective Definitions for Fuzzy Linguistic Hedges	New and more general definitions of hedges are presented and illustrated with graphs. It is hoped that these general formulae will provide more versatility to both fuzzy theorists and application engineers.
Hemlata Aggarwal, H.D. Arora, Vijay Kumar	A Decision Making Problem as an Application Of Fuzzy Sets	Apply the fuzzy sets in the decision-making process. It may apply to many fields with problems containing uncertainty.
Krishna Gogoi, Alock Kr. Dutta, Chandra Chutia	Application of Fuzzy Soft Set Theory in Day to Day Problems	Select a burning problem for the parents and successfully applied the Fuzzy soft set theory in decision making.
Shaily Thaker, Viral Nagori	Analysis of Fuzzification Process in Fuzzy Expert System	The selection of the membership function is found to be an integral part of the fuzzification process, which plays an important role in the Fuzzy Expert system's success.

Table 2.4.1 The previous research using Fuzzy Logic

2.4.2 Benchmarking as TRIZ tools

Based on Zhang, Chai, and Tan (2005), this article demonstrates the viability of applying the theory of inventive problem solving (TRIZ) to services by proposing

a new method to identify, generate, and evaluate possible solutions to service problems. The outcome of the model is a series of possible solutions that can be further developed into service concepts (Clark, Johnston, and Shulver 2000; Edvardsson and Olsson 1996; Johnson et al. 2001). The article is arranged in the following manner. We first evaluate prior studies in service architecture and the required instruments. A summary of the theoretical structure of TRIZ methods follows this. The use of TRIZ in service architecture is demonstrated using two analytical case studies. Finally, we address the study's contributions and managerial effects. Several avenues for future studies are proposed based on the shortcomings found. [12]

Tessari, R. K., De Carvalho, M. (2015) states that Heuristics are widely accepted and used as tools for inventive problem-solving. Problem-solving can be defined as the process of gathering people and resources to analyze a situation, determine the real problem, propose and evaluate solutions, and choose the best one that fulfills their needs. With such qualities, heuristics techniques are popular, playing a major role in TRIZ (Theory of Inventive Problem Solving). TRIZ heuristics have been abstracted into a generalized problem-solving system from the most innovative patents, allowing the solution of the most diverse particular problems. Popular examples are "Do it in reverse," a heuristic that means that the user does the opposite behavior or examines a configuration or property opposite to the one in the initial case, and "Union or Consolidation," which implies that more tasks are done by one entity, something that can be found today in electronic devices. [13]

Simon Dewulf states that the overall method of ‘global benchmarking’ presented here consists of three main parts. The significance of discontinuity in assessing innovation performance is primarily driven by the inclusion of these pieces.

As shown in Figure 1, by moving s-curves, effective developments appear. These changes may take place at the level of individual elements, at the overall level of the structure, or any intermediate level of the hierarchy. The three key processes by which structures progress from one s-curve to the next also include:

· the resolution of a conflict or contradiction

· shifting to another means of delivering a function

· shifting to another stage on the map of discontinuous trend jumps

The article examines each of these three mechanisms individually in the context of the thermal comfort case study. [14]

Crom, Steve states that for global enterprises that have pockets of excellence but a tradition of autonomy rather than collaboration, internal benchmarking is ideal. To be useful for internal benchmarking, it has to be coupled with the resources to enforce process improvement. While the two operations need to be integrated, documenting best practices and not making enhancement recommendations to their benchmark hosts is most effective for an internal benchmarking team. A self-assessment guide helps users sort out the most relevant information. Above all, a practical strategy/plan for process enhancement must be in a location supported by the management of the company. [15]

Dr.-Ing. Kai Mertins, Dipl.-Ing. S. Kempf, Dipl.-Ing. G. Siebert states that Benchmark solutions, regardless of whether internal or external benchmarks are concerned, are always only as good as the respective benchmarking partner. The range of issues that are faced by every Benchmarked derives from that. In the sense of KVP

or Kaizen, Benchmarking will be completed as an instrument which managers will use in daily life just like using the telephone: Initiation to changes; instruction of strategy recommendations that must be hardly acquired then; continuous Benchmarking circuits, report of an alteration plan. Benchmarking helps to gain a competitive advantage and to retain this competitive role. [16]

Larisa Dragolea & Cotirlea, Denisa states that Instead of analyzing situations and processes and helping to improve performance, benchmarking does not provide a solution to all the issues. It is a continuous process of enhancement. The benchmarking exercises are therefore properly applied and regularly performed to gain a competitive advantage and also to refine performance in the main business areas. [17]

Author	Title	Result/Description
Kah-Hin Chai, Jun Zhang, Kay-Chuan Tan	A TRIZ-Based Method for New Service Design	In comparison to non-technical data, TRIZ could have been generated based on technological knowledge. Nevertheless, the willingness to unleash innovation in the service sector holds great promise.
Tessari, R. K., De Carvalho, M.	Rules for Problem Solving: Qualitative Analysis and Compilation of Existing Inventive Heuristics of TRIZ	The chronological view made it easy to comprehend the origins of several Heuristics have recently been proposed and a significant number of non-original ones have been discarded. This could support TRIZ to Growth, since, as well as its weaknesses and holes, its strengths are made simpler.
Simon Dewulf	CASE STUDY in TRIZ: 'Global Benchmark' Evaluation of Thermal	Sparse evidence and a significant measure of gut feelings are usually the conventional ways of assessing future policy. TRIZ makes it possible for the first

	Comfort in Sports Equipment	time to formulate and use quantifiable metrics to equate multiple solutions.
Crom, Steve	Internal Benchmarking: Identifying Best Practices within a Global Enterprise	For global businesses that have pockets of excellence, internal benchmarking is ideal.
Dr.-Ing. Kai Mertins, Dipl.-Ing. S. Kempf, Dipl.-Ing. G. Siebert	Benchmarking Techniques	Benchmark solutions, regardless of whether internal or external benchmarks are concerned, are always only as good as the respective benchmarking partner.
Larisa Dragolea & Cotirlea, Denisa	Benchmarking: Types of Benchmarking Application	Benchmarking does not provide all of the issues with a solution.

Table 2.4.2 The table previous research using TRIZ

2.5 Conclusion

This chapter offers a clearer view of the focus of the project involving Fuzzy Logic as AI tools and benchmarking as TRIZ tools. In general, each of the subjects is defined to illustrate how these approaches can be applied in this project. A theoretical comparison of previous research on problem-solving problems, fuzzy logic, and benchmarking approaches was proposed in the critical review section. The findings from this literature review are used to develop an effective research framework in comparing both methods fuzzy logic and benchmarking. The chapter will have explained in detail the methodology which greatly influenced this chapter's findings.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter explains in-depth the methodology used as a guide to ensure that the project is still in the right sequence and on schedule. In the course of completing the analysis, the technique often includes steps or procedures to reach those milestones. This is important to ensure that the project is accomplished by effectively executing the expected strategy within a specific timeline. The method of demonstrating the timeline and milestones involved in this project is selected as a Gantt chart. In explaining the sequence operation of this project as a whole and also its related experiments, the flowcharts are also used.

3.2 Methodology

The methodology is a collection of methods or how those methods are chosen to solve specific problems. The methodology is used in this study in the systematic review of processes that serve as a structure that explains how the mechanism can accomplish the objectives of the project. In this case, using fuzzy logic and benchmarking algorithm, the system was developed to solve TRIZ classification problems to the best possible degree. The methodology of this project involves six stages: previous study, collection of information, description of scope, design, and implementation, system testing and evaluation, and, finally, documentation. The relationship of each step is defined in Figure 10 as a single methodological model used in this project.

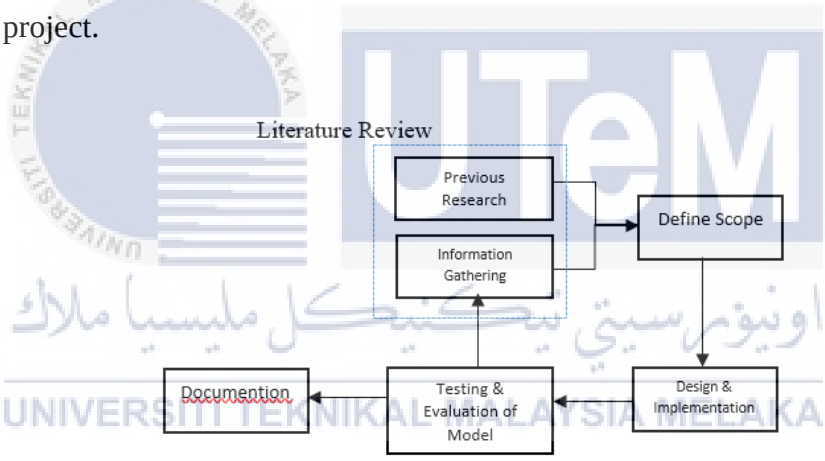

Figure 2.4.2-1 The Framework of the System

3.2.1 Previous Research

Based on previous studies, this step provides a deeper understanding and suggestions on how to execute the project. To identify a relevant research subject, the method will review domain-related papers based on their research weaknesses and potential research recommendations. The domain researched in this project is fuzzy logic, normalization, capping, and benchmarking. Previous studies will explain how the planned theoretical structures work in their respective fields, offering an insight

into how this research will be conducted. At this point, the specifics of this matter are discussed.

3.2.2 Information Gathering

The compilation of knowledge is aimed at gaining a solid understanding of research problems. It provides checked supporting evidence about how serious the problems are. To fix binary-based issues, most classification methods have been developed. On the other hand, this study will build a problem-solving model by using Benchmarking as a method for TRIZ. The collection of data from previous studies would reinforce the range of algorithms and methods used in this study to conduct experiments.

3.2.3 Define Scope

The size of the project is the threshold for the location of this report. This research was carried out to create applications or alternatives to solve problems in the collection of complicated objects and to make decisions easier for all, including students. The variables evaluated were the precision accuracy and uncertainty matrix between the model built and the benchmarks.

3.2.4 Design and Implementation

Figure 3.2.4-1 Research Methodology Flow Chart

Refer to section Appendix C.

Based on the analysis done in previous phases, this phase will identify the design and implementation of the new suggested models. First, the dataset is divided by Microsoft Excel into fuzzy logic and benchmarking, which also serves as a benchmark for this analysis. First, the technique of feature filtering, data gain, is used

to discard irrelevant features. The new feature set is then selected for use in Excel and the conclusions are drawn. The conclusion is the decision that is made from the methods used. These processes are explained as follow:

3.2.4.1 Collect data

1. Generate the Data Table

As stated earlier, this study aims to help individuals, especially students who have faced insufficient problems to make a decision based on complex choices.

First of all, the example data had been changed from SUV cars to affordable cars for fresh graduates due to current conditions. The cars changed to Myvi 1.3L X (A.S.A 2.0), Myvi 1.3L X, Bezza 1.3 X, Bezza 1.0 G, Axia 1.0 AV, Axia 1.0 SE, Iriz 1.3 Standard CVT, Iriz Executive CVT, Saga 1.3 Standard (AT), and Saga 1.3 Premium (AT). All the characteristics of these cars were listed as shown in the table below.

	Myvi 1.3L X (A.S.A 2.0)	Myvi 1.3L X	Bezza 1.3 X	Bezza 1.0 G	Axia 1.0 AV	Axia 1.0 SE	Iriz 1.3 Standard CVT	Iriz Executive CVT	Saga 1.3 Standard (AT)	Saga 1.3 Premium (AT)
Price	RM48,959.00	RM44,959.00	RM42,551.00	RM35,391.00	RM41,427.00	RM37,515.00	RM39,700.00	RM44,700.00	RM36,914.54	RM41,013.76
Insurance	RM1,100.00	RM1,100.00	RM1,200.00	RM1,200.00	RM1,000.00	RM1,000.00	RM1,100.00	RM1,100.00	RM1,100.00	RM1,100.00
Roadtax	RM70.00	RM70.00	RM80.00	RM80.00	RM80.00	RM80.00	RM70.00	RM70.00	RM70.00	RM70.00
Warranty	5 years / 300,000 km	5 years / 300,000 km	5 years / 300,000 km	5 years / 300,000 km	6 years / 300,000 km	7 years / 300,000 km	5 years / 150,000 km	5 years / 150,000 km	5 years / 150,000 km	5 years / 150,000 km
Colour	Electric Blue, Granite Grey, Lava Red, Ivory White, Glittering	Electric Blue, Granite Grey, Lava Red, Ivory White, Glittering	Ivory White, Garnet Red, Glittering Silver, Granite Grey, Ocean Blue, Sugar Brown	Ivory White, Garnet Red, Glittering Silver, Granite Grey, Ocean Blue, Sugar Brown	Lava Red, Midnight Blue, Glittering Silver, Ivory White	Lava Red, Midnight Blue, Glittering Silver, Ivory White	Snow White, Jet Grey, Armour Silver, Ruby Red, Ocean Blue	Snow White, Jet Grey, Armour Silver, Ruby Red, Ocean Blue	Ruby Red, Rosewood Maroon, Armour Silver, Jet Grey, Snow White	Ruby Red, Rosewood Maroon, Armour Silver, Jet Grey, Snow White
Engine Tech	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1KR-VE,4 DOHC, 12V, Electronic Fuel Injection (EFI) with Dual VVT-i	1KR-VE,4 DOHC, 12V, Electronic Fuel Injection (EFI) with Dual VVT-i	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT
Capacity (cc)	1,329	1,329	1,329	998	998	998	1,432	1,432	1,332	1,332
Transmission	4 E-AT	4 E-AT	4 E-AT	4 E-AT	Dual-clutch Automatic (Wet)	Dual-clutch Automatic (Wet)	CVT	CVT	4-Speed Automatic	4-Speed Automatic
Gears	7	7	5	5	7	7	7	7	6	6
Manufacturer	Perodua	Perodua	Perodua	Perodua	Perodua	Perodua	Proton	Proton	Proton	Proton
Performance 0-100km/h	7.9 seconds	7.9 seconds	7.9 seconds	7.9 seconds	7.9 seconds	No	No	No	No	No
Rated Economy (L/100KM)	21.1	21.1	3.6	3.6	6.4	6.5	6.5	6.5	6.4	6.4
Top Speed	220 km/h	220 km/h	200 km/h	200 km/h	195 km/h	No	No	No	No	No
Co2 Emission	No	No	No	No	No	No	No	No	No	No
Dimensions (L*W*H)	3895 mm*1,735 mm*1,515 mm	3895 mm*1,735 mm*1,515 mm	4,170 mm*1,620 mm*1,525 mm	4,170 mm*1,620 mm*1,525 mm	4,330 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,331 mm*1,689 mm*1,491 mm	4,331 mm*1,689 mm*1,491 mm
Fuel Tank (litres)	36	36	50	50	45	45	45	45	40	41
Boot Space (litres)	277	277	508	508	330	330	215	215	420	420
Autonomous Braking System	No	No	No	No	Yes	No	No	No	No	No
Parking Brake	Handbrake	Handbrake	Handbrake	Handbrake	Handbrake	Handbrake	Electronic	Electronic	Electronic	Electronic

Table 3.2.1 The various cars

2. Differentiate into Two Methods

These methods are tested by using Microsoft Excel. Microsoft Excel is used as the platform as these methods, fuzzy logic and benchmark need formula in every procedure.

(a) By using Fuzzy logic as TRIZ tools

Figure 3.2.4-2 The process by using the Fuzzy method

Refer to section Appendix D.

i. Insert the cars data in the MS EXCEL

	Myvi 1.3L X (A.B.A 2.0)	Myvi 1.3L X	Bezza 1.3 X	Bezza 1.0 G	Axia 1.0 AV	Axia 1.0 SE	Iriz 1.3 Standard CVT	Iriz Executive CVT	Saga 1.3 Standard (AT)	Saga 1.3 Premium (AT)
Price	RM46,959.00	RM44,959.00	RM42,551.00	RM35,391.00	RM41,427.00	RM37,515.00	RM39,700.00	RM44,700.00	RM36,914.54	RM41,013.76
Insurance	RM1,100.00	RM1,100.00	RM1,200.00	RM1,200.00	RM1,000.00	RM1,000.00	RM1,100.00	RM1,100.00	RM1,100.00	RM1,100.00
Roadtax	RM70.00	RM70.00	RM80.00	RM80.00	RM50.00	RM60.00	RM70.00	RM70.00	RM70.00	RM70.00
Warranty	5 years / 300,000 km	5 years / 300,000 km	5 years / 300,000 km	5 years / 300,000 km	6 years / 300,000 km	7 years / 300,000 km	5 years / 150,000 km	5 years / 150,000 km	5 years / 150,000 km	5 years / 150,000 km
Colour	Electric Blue, Granite Grey, Lava Red, Ivory White, Glittering	Electric Blue, Granite Grey, Lava Red, Ivory White, Glittering	Ivory White, Garnet Red, Glittering Silver, Granite Grey, Ocean Blue, Sugar Brown	Ivory White, Garnet Red, Glittering Silver, Granite Grey, Ocean Blue, Sugar Brown	Lava Red, Midnight Blue, Glittering Silver, Ivory White	Lava Red, Midnight Blue, Glittering Silver, Ivory White	Snow White, Jet Grey, Armour Silver, Ruby Red, Ocean Blue	Snow White, Jet Grey, Armour Silver, Ruby Red, Ocean Blue	Ruby Red, Rosewood Maroon, Armour Silver, Jet Grey, Snow White	Ruby Red, Rosewood Maroon, Armour Silver, Jet Grey, Snow White
Engine Tech	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1KR-VE,4 DOHC, 12V, Electronic Fuel Injection (EFi) with Dual VVT-i	1KR-VE,4 DOHC, 12V, Electronic Fuel Injection (EFi) with Dual VVT-i	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT
Capacity (cc)	1,329	1,329	1,329	998	998	998	1,432	1,432	1,332	1,332
Transmission	4 E-AT	4 E-AT	4 E-AT	4 E-AT	Dual-clutch Automatic (Wet)	Dual-clutch Automatic (Wet)	CVT	CVT	4-Speed Automatic	4-Speed Automatic
Gears	7	7	6	6	7	7	7	7	6	6
Manufacturer	Perodua	Perodua	Perodua	Perodua	Perodua	Perodua	Proton	Proton	Proton	Proton
Performance 0-100km/h	7.9 seconds	7.9 seconds	7.9 seconds	7.9 seconds	7.9 seconds	No	No	No	No	No
Rated Economy (L/100KM)	21.1	21.1	3.6	3.6	6.4	6.5	6.5	6.5	6.4	6.4
Top Speed	220 km/h	220 km/h	200 km/h	200 km/h	195 km/h	No	No	No	No	No
Co2 Emission	No	No	No	No	No	No	No	No	No	No
Dimensions (L*W*H)	3895 mm*1,735 mm*1,515 mm	3896 mm*1,735 mm*1,515 mm	4,170 mm*1,620 mm*1,525 mm	4,170 mm*1,620 mm*1,325 mm	4,330 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,331 mm*1,689 mm*1,491 mm	4,331 mm*1,689 mm*1,491 mm
Fuel Tank (litres)	36	36	50	50	45	45	45	45	40	41
Boot Space (litres)	277	277	508	508	330	330	215	215	420	420
Autonomous Braking System	No	No	No	No	YES	No	No	No	No	No
Parking Brake	Handbrake	Handbrake	Handbrake	Handbrake	Handbrake	Handbrake	Electronic	Electronic	Electronic	Electronic

Table 3.2.2 10 different types of cars

ii. Convert the data into membership

	Price	Insurance	Roadtax	Warranty	Colour	Engine Tech	Capacity	Transmission	Gears	Manufacturer	Performance 0-100km/h	Rated Economy	Top Speed	Co2 Emission	Dimensions (L*W*H)	Fuel Tank	Boot Space	Autonomous Braking System	Parking Brake
Myvi 1.3L X (A.S.A 2.0)	0.05	0.05	0.44	0.300	0.500	0.400	0.886	0.300	0.100	0.300	0.575	0.211	0.192	0.100	0.144	0.360	0.277	0.110	0.200
Myvi 1.3L X	0.04	0.73	0.10	0.200	0.500	0.500	0.886	0.400	0.700	0.200	0.395	0.211	0.204	0.144	0.116	0.360	0.277	0.250	0.100
Bezza 1.3 X	0.04	0.80	0.44	0.200	0.400	0.200	0.886	0.200	0.600	0.200	0.500	0.036	0.194	0.169	0.116	0.500	0.508	0.120	0.100
Bezza 1.0 G	0.04	0.80	0.44	0.200	0.200	0.200	0.665	0.200	0.600	0.200	0.500	0.036	0.194	0.169	0.116	0.500	0.508	0.130	0.100
Axia 1.0 AV	0.04	0.67	0.10	0.300	0.600	0.100	0.665	0.100	0.700	0.100	0.395	0.064	0.195	0.100	0.125	0.450	0.330	0.200	0.200
Axia 1.0 SE	0.04	0.67	0.10	0.300	0.600	0.100	0.665	0.100	0.700	0.100	0.100	0.065	0.100	0.100	0.125	0.450	0.330	0.140	0.200
Iriz 1.3 Standard CVT	0.04	0.73	0.10	0.300	0.500	0.100	0.955	0.100	0.700	0.100	0.100	0.065	0.100	0.100	0.125	0.450	0.215	0.150	0.200
Iriz Executive CVT	0.04	0.73	0.10	0.300	0.300	0.100	0.955	0.100	0.700	0.100	0.100	0.065	0.100	0.100	0.125	0.450	0.215	0.160	0.200
Saga 1.3 Standard (AT)	0.04	0.73	0.10	0.300	0.500	0.300	0.888	0.300	0.100	0.300	0.610	0.064	0.100	0.100	0.130	0.400	0.420	0.170	0.100
Saga 1.3 Premium (AT)	0.04	0.73	0.44	0.100	0.800	0.600	0.888	0.200	0.600	0.400	0.100	0.064	0.100	0.100	0.121	0.410	0.420	0.180	0.200

Table 3.2.3 The converted data into the numbering data

iii. Set the capping value

Questions	Answer
1) The price that you preferred?	5
2) Insurance that you preferred?	1 / 2 / 3 / 4 / 5
3) Roadtax that you preferred?	
4) Warranty that you preferred?	
5) Colour that you preferred?	2
6) Engine Tech that you preferred?	5
7) Capacity that you preferred?	5

Figure 3.2.4-3 The answer inserted by the respondents

	Capping values
Price	5
Insurance	5
Roadtax	3
Warranty	5
Colour	2
Engine Tech	5
Capacity	5
Transmission	4
Gears	2
Manufacturer	4
Performance 0-100km/h	4
Rated Economy	4
Top Speed	4
Co2 Emission	3
Dimensions (L*W*H)	2
Fuel Tank	3
Boot Space	2
Autonomous Braking System	4
Parking Brake	3

Table 3.2.4 The capping value inserted is used for the capping value

iv. Normalization

	Price
Capping values	0.01
Myvi 1.3L X (A.S.A 2.0)	=C64/C63
Myvi 1.3L X	0.01
Bezza 1.3 X	0.01
Bezza 1.0 G	0.01
Axia 1.0 AV	0.01
Axia 1.0 SE	0.01
Iriz 1.3 Standard CVT	0.01
Iriz Executive CVT	0.01
Saga 1.3 Standard (AT)	0.01
Saga 1.3 Premium (AT)	0.01

Figure 3.2.4-4 The normalization step where the data is divided by the capping value

v. Preference Ranking

	Price
Capping values	0.9906 ×
Myvi 1.3L X (A.S.A 2.0) Price: RM 46,959	=1-C78
Myvi 1.3L X Price: RM44,959	0.9910
Bezza 1.3 X Price: RM42,551	0.9915
Bezza 1.0 G Price: RM 35,391	0.9929
Axia 1.0 AV Price: RM41,427	0.9917
Axia 1.0 SE Price: RM37,515	0.9925
Iriz 1.3 Standard CVT Price: RM39,700	0.9921
Iriz Executive CVT Price: RM44700	0.9911
Saga 1.3 Standard (AT) Price: RM36,914.54	0.9926
Saga 1.3 Premium (AT) Price: RM41,013.76	0.9918

Figure 3.2.4-5 The complement or negation of the data (Price)

vi. Find min for every category

Autonomous Braking System	Parking Brake	
4	3	min
0.0275	0.0667	0.028
0.0625	0.0333	0.032
0.0300	0.0333	=MIN(C94:U94)
0.0325	0.0333	0.033
0.0500	0.0667	0.020
0.0350	0.0667	0.020
0.0375	0.0667	0.020
0.0400	0.0667	0.020
0.0425	0.0333	0.025
0.0450	0.0667	0.020

Figure 3.2.4-6 The minimum value for the characteristics of all cars

vii. Find max among the min

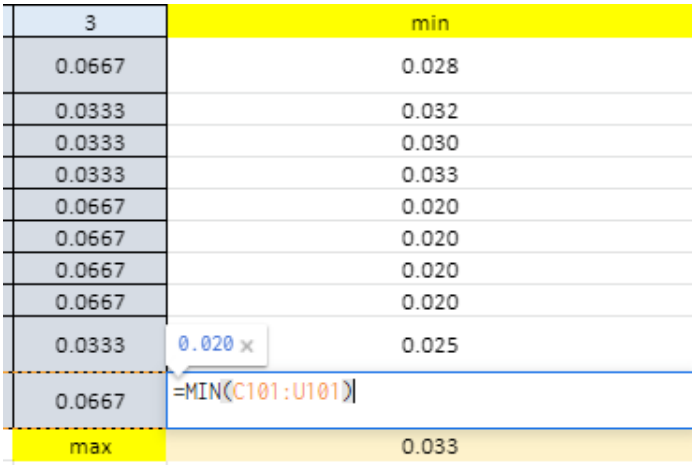

Figure 3.2.4-7 The maximum value of the minimum values for each characteristic

viii. Conclusion

Figure 3.2.4-8 The car selected from the calculations

Figure 3.2.4-9 The conclusion that shown for the respondents

(b) By using Benchmarking as TRIZ tools

Figure 3.2.4-10 The process by using the Benchmarking method

Refer to section Appendix E.

i. Insert the cars data in the MS EXCEL

	Myvi 1.3L X (A.S.A 2.0)	Myvi 1.3L X	Bezza 1.3 X	Bezza 1.0 G	Axia 1.0 AV	Axia 1.0 SE	Iriz 1.3 Standard CVT	Iriz Executive CVT	Saga 1.3 Standard (AT)	Saga 1.3 Premium (AT)
Price	RM46,959.00	RM44,959.00	RM42,551.00	RM35,391.00	RM41,427.00	RM37,515.00	RM39,700.00	RM44,700.00	RM36,914.54	RM41,013.76
Insurance	RM1,100.00	RM1,100.00	RM1,200.00	RM1,200.00	RM1,000.00	RM1,000.00	RM1,100.00	RM1,100.00	RM1,100.00	RM1,100.00
Roadtax	RM70.00	RM70.00	RM80.00	RM80.00	RM60.00	RM60.00	RM70.00	RM70.00	RM70.00	RM70.00
Warranty	5 years / 300,000 km	5 years / 300,000 km	5 years / 300,000 km	5 years / 300,000 km	6 years / 300,000 km	7 years / 300,000 km	5 years / 150,000 km	5 years / 150,000 km	5 years / 150,000 km	5 years / 150,000 km
Colour	Electric Blue, Granite Grey, Lava Red, Ivory White, Glittering	Electric Blue, Granite Grey, Lava Red, Ivory White, Glittering	Ivory White, Garnet Red, Glittering Silver, Granite Grey, Ocean Blue, Sugar Brown	Ivory White, Garnet Red, Glittering Silver, Granite Grey, Ocean Blue, Sugar Brown	Lava Red, Midnight Blue, Glittering Silver, Ivory White	Lava Red, Midnight Blue, Glittering Silver, Ivory White	Snow White, Jet Grey, Armour Silver, Ruby Red, Ocean Blue	Snow White, Jet Grey, Armour Silver, Ruby Red, Ocean Blue	Ruby Red, Rosewood Maroon, Armour Silver, Jet Grey, Snow White	Ruby Red, Rosewood Maroon, Armour Silver, Jet Grey, Snow White
Engine Tech	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1NR-VE,4 cylinders, DOHC with Dual VVT-i	1KR-VE,4 DOHC, 12V, Electronic Fuel Injection (EFI) with Dual VVT-i	1KR-VE,4 DOHC, 12V, Electronic Fuel Injection (EFI) with Dual VVT-i	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT	4 cylinder In-Line 16-valve DOHC, VVT
Capacity (cc)	1,329	1,329	1,329	998	998	998	1,432	1,432	1,332	1,332
Transmission	4 E-AT	4 E-AT	4 E-AT	4 E-AT	Dual-clutch Automatic (Wet)	Dual-clutch Automatic (Wet)	CVT	CVT	4-Speed Automatic	4-Speed Automatic
Gears	7	7	6	6	7	7	7	7	6	6
Manufacturer	Perodua	Perodua	Perodua	Perodua	Perodua	Perodua	Proton	Proton	Proton	Proton
Performance 0-100km/h	7.9 seconds	7.9 seconds	7.9 seconds	7.9 seconds	7.9 seconds	No	No	No	No	No
Rated Economy (L/100KM)	21.1	21.1	3.6	3.6	6.4	6.5	6.5	6.5	6.4	6.4
Top Speed	220 km/h	220 km/h	200 km/h	200 km/h	185 km/h	No	No	No	No	No
Co2 Emission	No	No	No	No	No	No	No	No	No	No
Dimensions (L*W*H)	3895 mm*1,735 mm*1,515 mm	3896 mm*1,735 mm*1,515 mm	4,170 mm*1,620 mm*1,525 mm	4,170 mm*1,620 mm*1,525 mm	4,530 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,330 mm*1,800 mm*1,609 mm	4,331 mm*1,689 mm*1,491 mm	4,331 mm*1,689 mm*1,491 mm
Fuel Tank (litres)	36	36	50	50	45	45	45	45	40	41
Boot Space (litres)	277	277	508	508	330	330	215	215	420	420
Autonomous Braking System	No	No	No	No	No	No	No	No	No	No
Parking Brake	Handbrake	Handbrake	Handbrake	Handbrake	Handbrake	Handbrake	Electronic	Electronic	Electronic	Electronic

Table 3.2.5 10 different types of cars

ii. Convert the data into membership

	Price	Insurance	Roadtax	Warranty	Colour	Engine Tech	Capacity	Transmission	Gears	Manufacturer	Performance (0-100km/h	Rated Economy	Top Speed	Co2 Emission	Dimensions (L*W*H)	Fuel Tank	Boot Space	Autonomous Braking System	Parking Brake
Myvi 1.3L X (A.S.A 2.0)	0.05	0.05	0.44	0.300	0.500	0.400	0.886	0.300	0.100	0.300	0.575	0.211	0.192	0.100	0.144	0.360	0.277	0.110	0.200
Myvi 1.3L X	0.04	0.73	0.10	0.200	0.500	0.500	0.886	0.400	0.700	0.200	0.395	0.211	0.204	0.144	0.116	0.360	0.277	0.250	0.100
Bezza 1.3 X	0.04	0.80	0.44	0.200	0.400	0.200	0.886	0.200	0.600	0.200	0.500	0.036	0.194	0.169	0.116	0.500	0.508	0.120	0.100
Bezza 1.0 G	0.04	0.80	0.44	0.200	0.200	0.200	0.665	0.200	0.600	0.200	0.500	0.036	0.194	0.169	0.116	0.500	0.508	0.130	0.100
Axia 1.0 AV	0.04	0.67	0.10	0.300	0.600	0.100	0.665	0.100	0.700	0.100	0.395	0.064	0.195	0.100	0.125	0.450	0.330	0.200	0.200
Axia 1.0 SE	0.04	0.67	0.10	0.300	0.600	0.100	0.665	0.100	0.700	0.100	0.100	0.065	0.100	0.100	0.125	0.450	0.330	0.140	0.200
Iriz 1.3 Standard CVT	0.04	0.73	0.10	0.300	0.500	0.100	0.955	0.100	0.700	0.100	0.100	0.065	0.100	0.100	0.125	0.450	0.215	0.150	0.200
Iriz Executive CVT	0.04	0.73	0.10	0.300	0.300	0.100	0.955	0.100	0.700	0.100	0.100	0.065	0.100	0.100	0.125	0.450	0.215	0.160	0.200
Saga 1.3 Standard (AT)	0.04	0.73	0.10	0.300	0.500	0.300	0.888	0.300	0.100	0.300	0.610	0.064	0.100	0.100	0.130	0.400	0.420	0.170	0.100
Saga 1.3 Premium (AT)	0.04	0.73	0.44	0.100	0.800	0.600	0.888	0.200	0.600	0.400	0.100	0.064	0.100	0.100	0.121	0.410	0.420	0.180	0.200

Table 3.2.6 the converted data into the numbering data

iii. Set the weight (1-5)

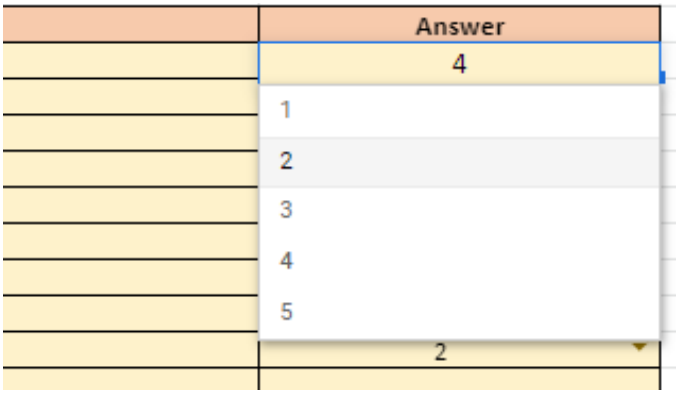

Figure 3.2.4-11 The set of questions that will be answered.

	Weight
Price	4
Insurance	5
Roadtax	3
Warranty	4
Colour	5
Engine Tech	5
Capacity	5
Transmission	4
Gears	2
Manufacturer	4
Performance 0-100km/h	4
Rated Economy	4
Top Speed	4
Co2 Emission	3
Dimensions (L*W*H)	3
Fuel Tank	3
Boot Space	2
Autonomous Braking System	4
Parking Brake	3

Table 3.2.7 the weight value based on the inserted answer

iv. Normalization

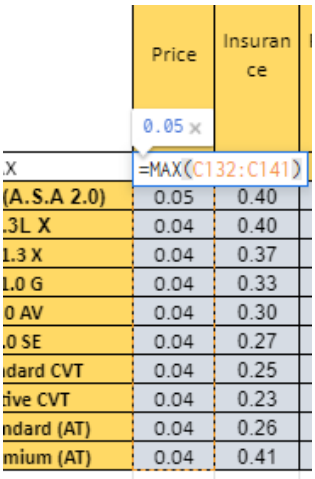

Figure 3.2.4-12 The maximum of the data by category

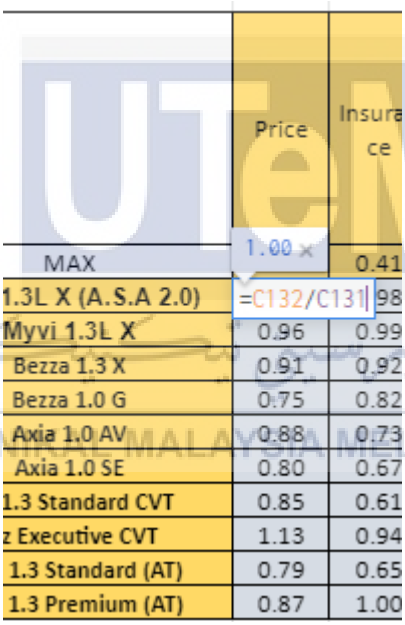

Figure 3.2.4-13 The data divided by the maximum value

v. Total up the normalization value

Tank	Space	g System	Brake	Total
3.00	2.00	4.00	3.00	59.25 ×
3.00	2.00	1.33	3.00	=SUM(C159:U159)
2.63	1.38	4.00	1.50	55.95
2.63	1.38	1.33	1.50	52.06
2.63	1.38	1.33	1.50	49.71
2.37	1.26	2.67	3.00	47.76

Figure 3.2.4-14 The sum value for every car

vi. Determine the max value

3.00	Total
3.00	59.25
1.50	55.95
1.50	52.06
1.50	49.71
3.00	47.76
3.00	42.02
3.00	41.32
3.00	69.21
1.50	46.55
3.00	69.21 × 54.63
max	=MAX(V159:V168)

Figure 3.2.4-15 The maximum of the total sum

vii. Conclusion

3.00	54.63
max	69.21
	Saga 1.3 Premium (AT) Price: RM41,013.76

Figure 3.2.4-16 The car selected from the calculations

The best data package that suitable for your choices is	69.21	Saga 1.3 Premium (AT) Price: RM41,013.76

Figure 3.2.4-17 The conclusion that is shown for the respondents.

3. Distribute to 90 respondents

90 respondents are the target scope of this study. All these 90 respondents will be included from UTeM students. The survey will be distributed to them by using an interactive form. All the questions will be asked whether it is towards 1(yes) or 0(no).

i) Data Collection by Using Google Form

Google Forms is a free online tool from Google that allows users to create forms, surveys, and quizzes, as well as update and share them collaboratively. [18]

Figure 3.2.4-18 Google form logo

Google Form is selected as the platform to experiment as it offers an easy data collection method for researchers. This survey by using Google Form is distributed by using links to students in UTeM. UTeM students are the main focus for this alternative as the main reason of the survey to collect responses about the car that suitable for the fresh graduates.

The type of questions for this survey is about cars. Cars that suitable for the fresh graduates includes Myvi 1.3L X (A.S.A 2.0), Myvi 1.3L X, Bezza 1.3 X, Bezza 1.0 G, Axia 1.0 AV, Axia 1.0 SE, Iriz 1.3 Standard CVT, Iriz Executive CVT, Saga 1.3 Standard (AT), and Saga 1.3 Premium (AT). These 10 cars are affordable cars that are usually used by fresh graduates. However, choosing a car to buy is quite confusing and it needs a method of solutions. By performing this survey, students help to choose which method that suitable to choose the cars.

There are two types of methods in this survey. The methods are the Fuzzy Method and Benchmarking Method. Based on the survey, a method that preferred the most students would be selected as the best method. Also, to ensure the Feasibility of the TRIZ Benchmarking Tool as A Decision-Making Algorithm, this platform of the survey needs to be performed.

ii) The Questions in The Form

There are four sections of questions on this form.

i. Section 1of 4 is students' email. In this section, students need to insert their email to collect their valid email.

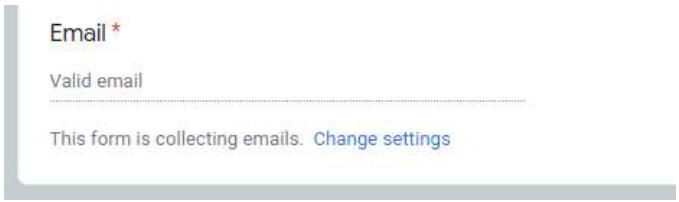

Figure 3.2.4-19 Section 1 of 4, collecting email

ii. Section 2 of 4 is students' information. In this section, students need to insert their information like age range, gender, ethnics, educational level, and course field in education.

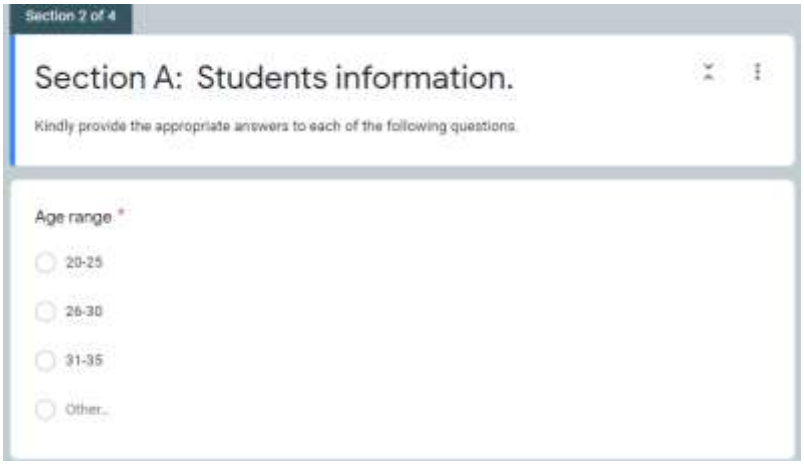

Figure 3.2.4-20 The section 2 of 4, age range

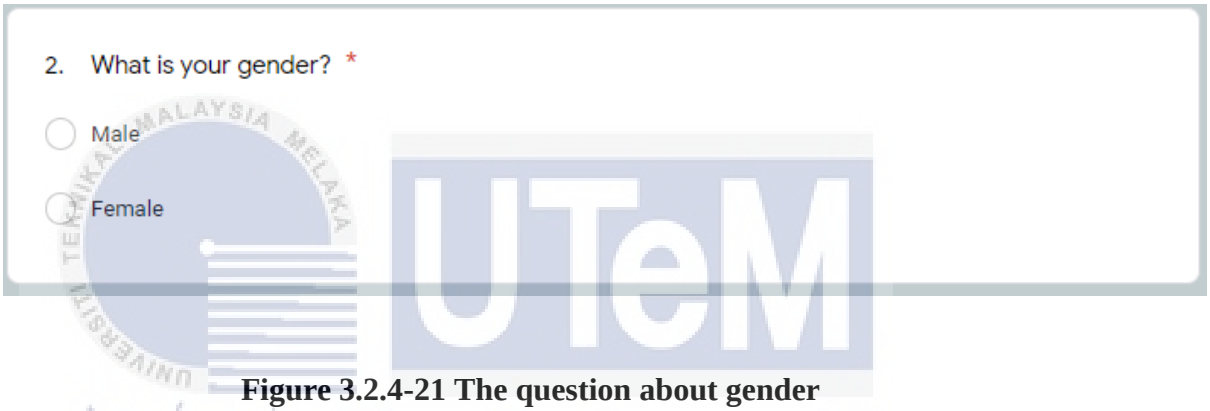

Figure 3.2.4-21 The question about gender

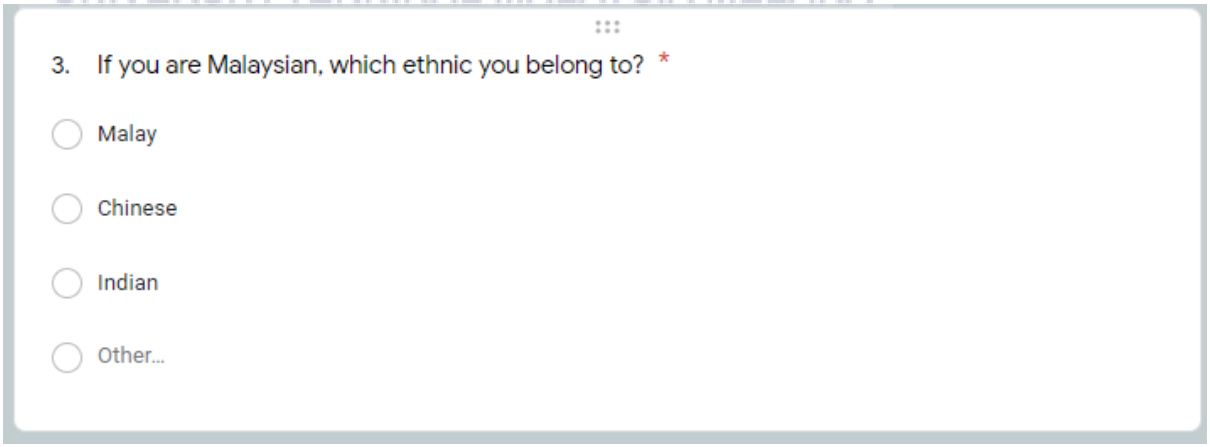

Figure 3.2.4-22 The question about ethnics

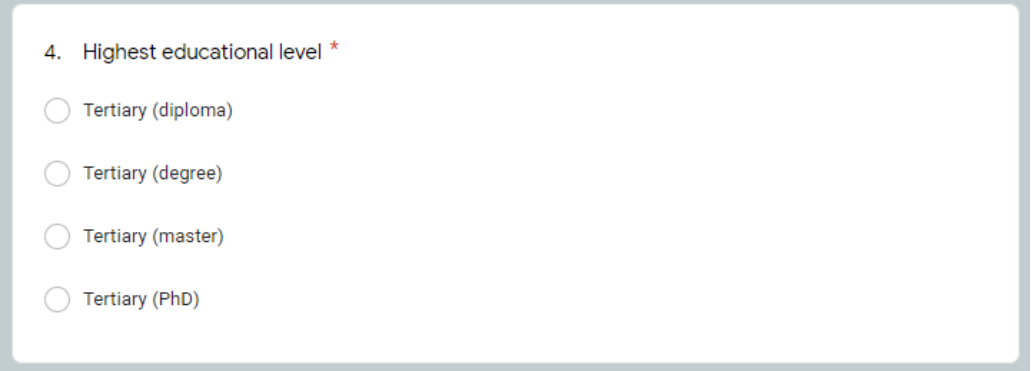

Figure 3.2.4-23 The question about highest education (for now)

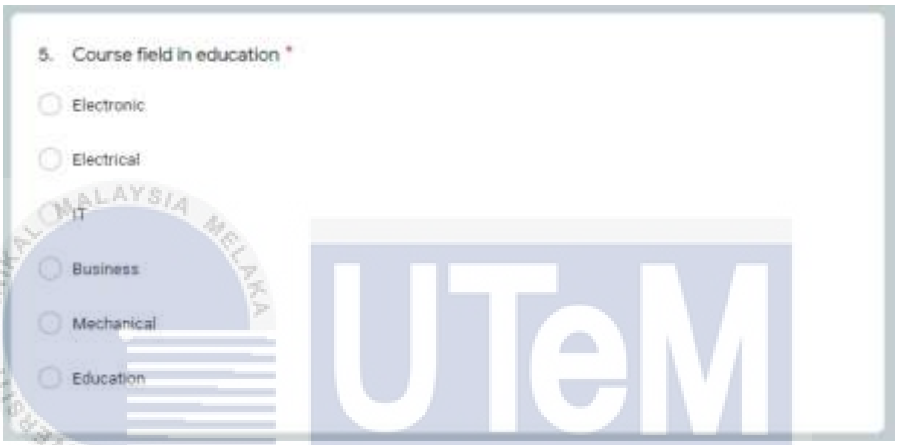

Figure 3.2.4-24 The main course field

iii. Section 3 of 4 is about the methods. In this section, students need to insert their capping values from 1 to 5. Value 1 is very low, 2 is low, 3 is medium, 4 is high, 5 is very high. This section needs to answer by referring to the spreadsheet link given.

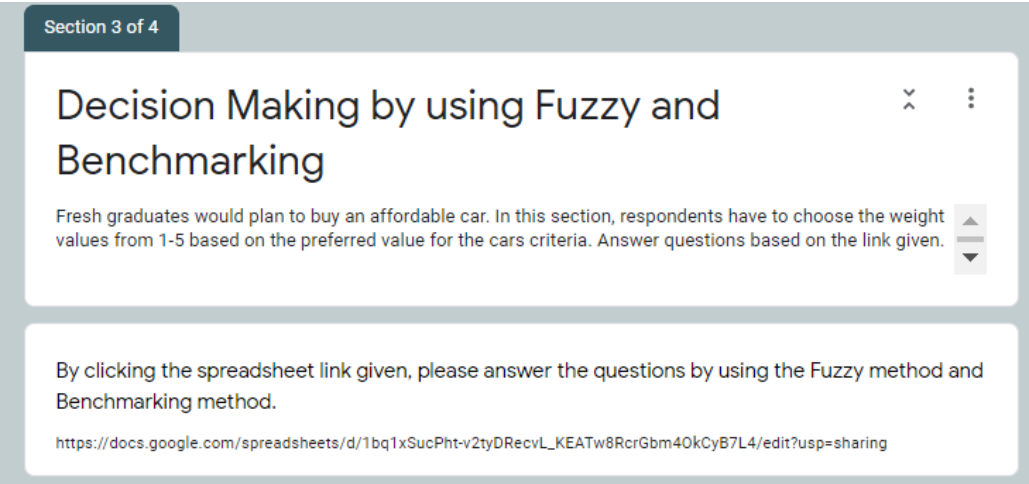

Figure 3.2.4-25 The section 3 of 4 and the linked spreadsheet

All these questions need to answer by referring to the spreadsheet that contains the formula of the Fuzzy method and Benchmarking method.

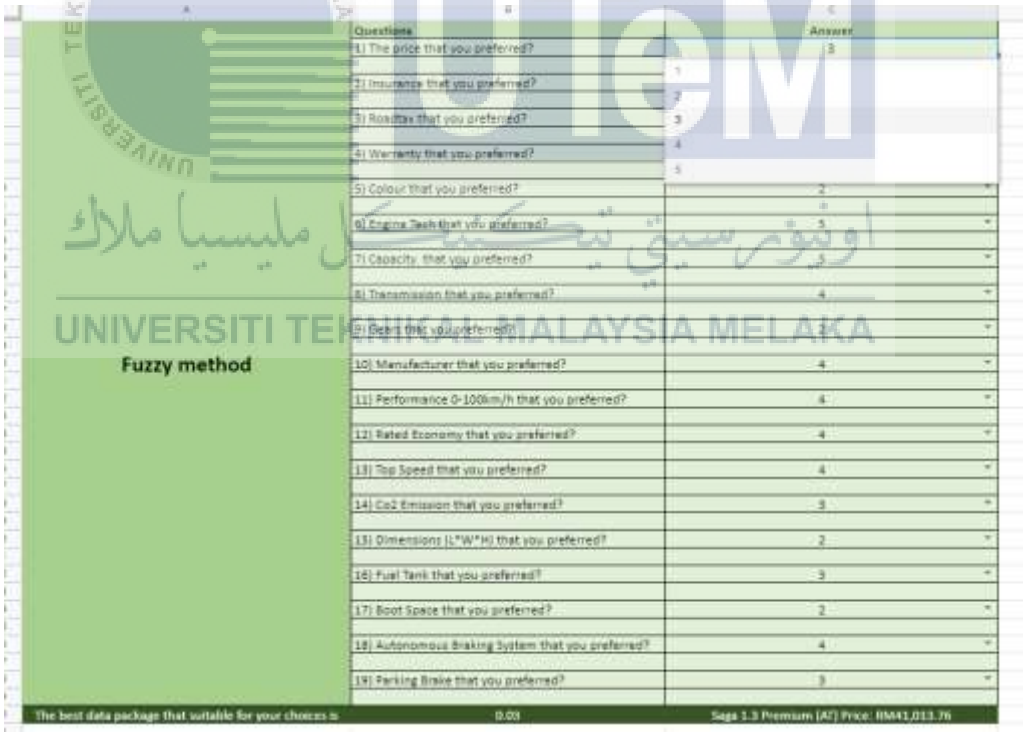

Figure 3.2.4-26 The fuzzy method questions

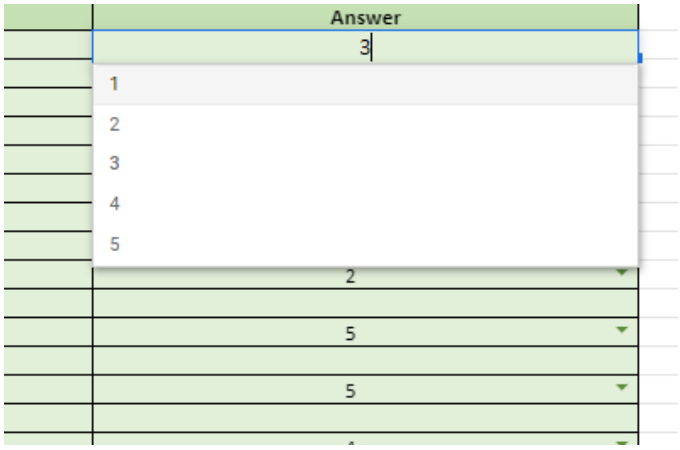

Figure 3.2.4-27 The answer form of this method

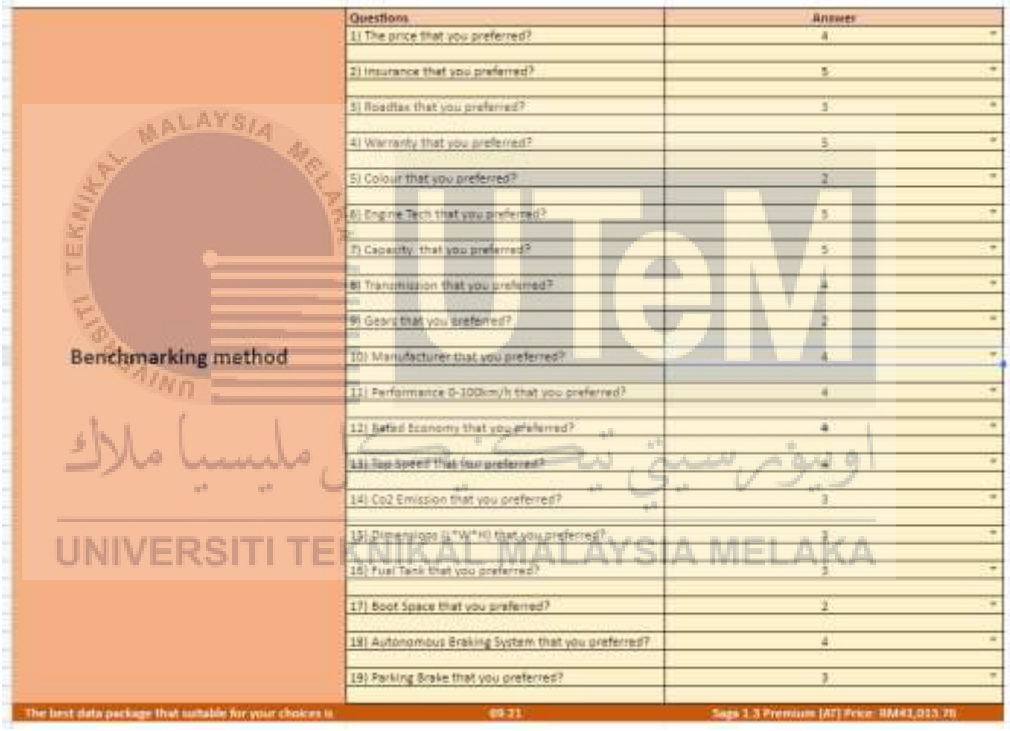

Figure 3.2.4-28 The benchmarking method questions in a google spreadsheet

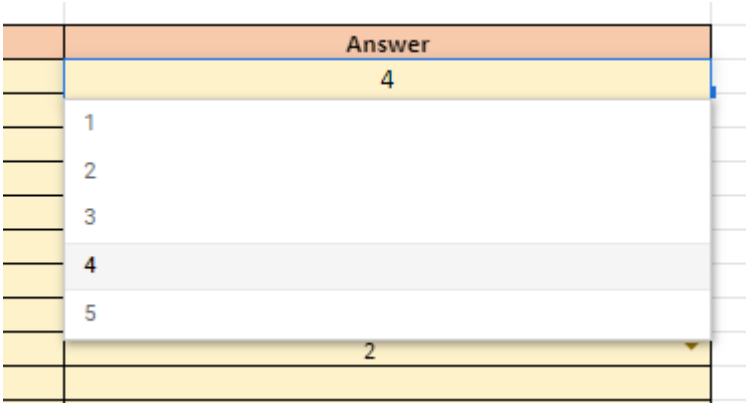

Figure 3.2.4-29 The answer form for this method in a google spreadsheet

iv. Section 4 of 4 is about the summary of the output from student's choices. In this section, students need to give their decision of which method that they preferred.

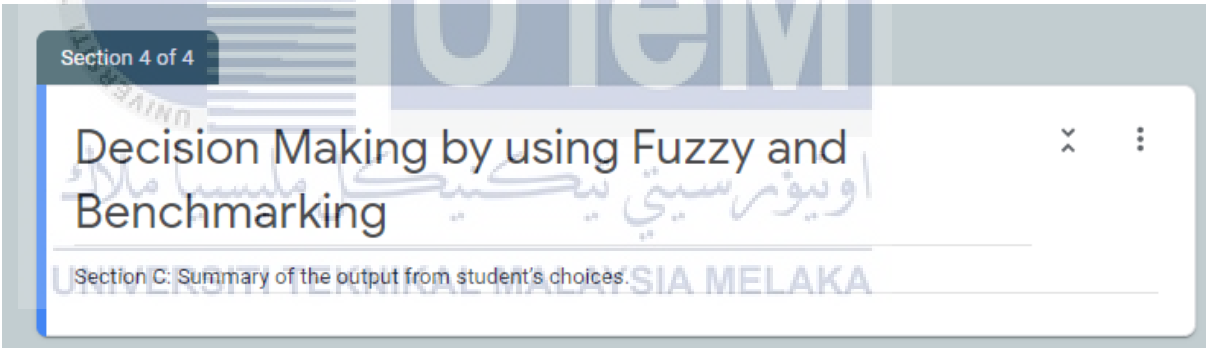

Figure 3.2.4-30 The header of Section C: Summary of the output from students' choice

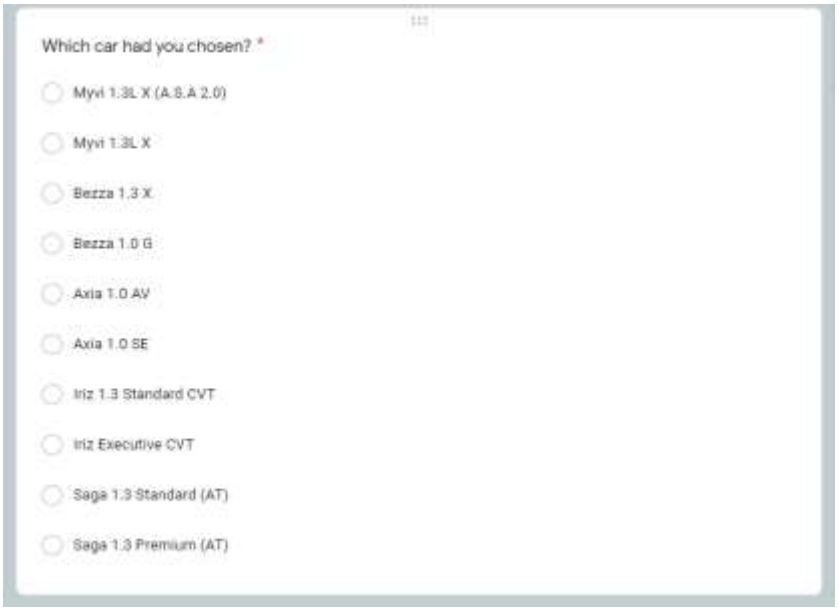

Figure 3.2.4-31 The question of car that they select by the method

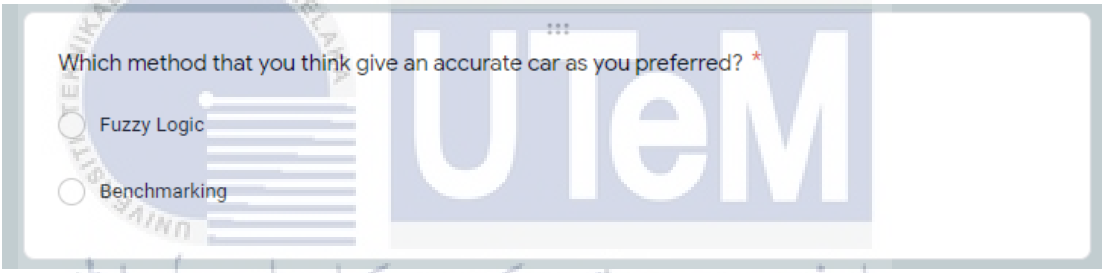

Figure 3.2.4-32 The question of method that preferred

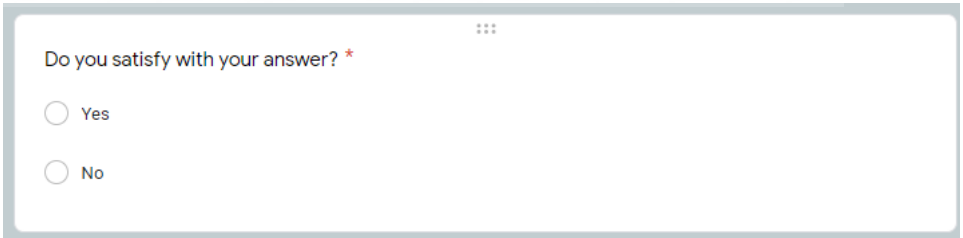

Figure 3.2.4-33 The question of satisfaction of respondents

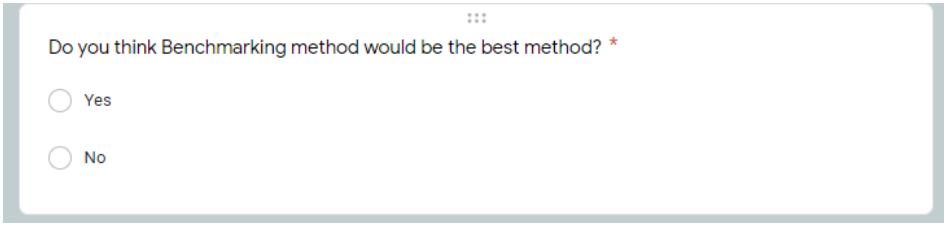

Figure 3.2.4-34 The question of benchmarking would be the best method

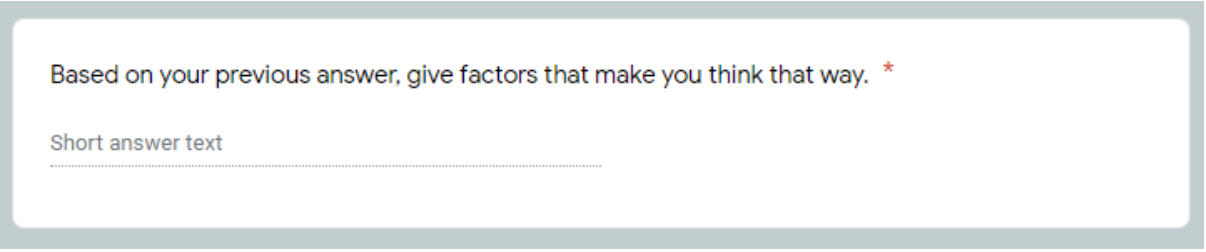

Figure 3.2.4-35 The question to give support factors

4. Identify the final decisions

The final options will be defined based on customer satisfaction. The decision must comply with desired customer decisions.

5. Collect the answers

The answers from the respondents will be collected and then they will be analyzed.

5. Analyze the findings

Based on customer satisfaction, the final options will be specified. The decision must comply with customer decisions that are desired.

3.2.5 Testing and Evaluation of Model

The purpose of the testing and evaluation process was to decide if the model produced satisfied the predefined specification. In this case, the model produced at the end of the process will compare its precision accuracy with the outcome of decisions taken earlier by both approaches. Their uncertainty matrices are additional features that are contrasted. To display the false positive predictions, the Confusion matrix was used. The model with low false positive numbers is considered to be the best. However, by reviewing previous research literature, a hypothesis is made beforehand,

it claimed that TRIZ benchmarking is a problem solving that will offer a better accuracy of precision. It may be used as a decision-making instrument. A model based on benchmarking needs to be built for an effective and consistent outcome. Thus, with a series of experiments, the purpose of this research is to test the hypothesis. Future work for this study's changes may come up with a detailed model assessment.

3.2.6 Documentation

The method of reporting assists in arranging the results into a more organized and correct form. Both methods, restrictions, and outcomes in proper documents that serve as a guide and proof of each operation are properly written for each experiment. To achieve its objectives, this project needs several complicated procedures. It would be a nightmare with no proper reporting plan to keep track and handle all of it. All relevant information is first identified and documented in their respective sections.

3.3 Project Schedule and Milestones

The tasks or procedures involved in this project are specified in the project schedule. It must comply with a certain strict timeline that involves certain stages. To ensure the project is still on track, the targets are set at certain particular points. For this, to describe the schedule and milestones involved, a Gantt map is used. It is a graph that displays time-based events.

A flowchart was often used to systematically include a description of the activities and their relationships. To avoid any delay or future constraints, this stage will also define the required resources that are mapped with their respective activities. A clear completion time is provided for an assignment that must be followed to complete this project within the timeline. An outstanding project scheduling and plan would lead to an outstanding outcome.

3.3.1 Project Flowchart

Figure 3.2 shows the flowchart of the general phases involved in this project.

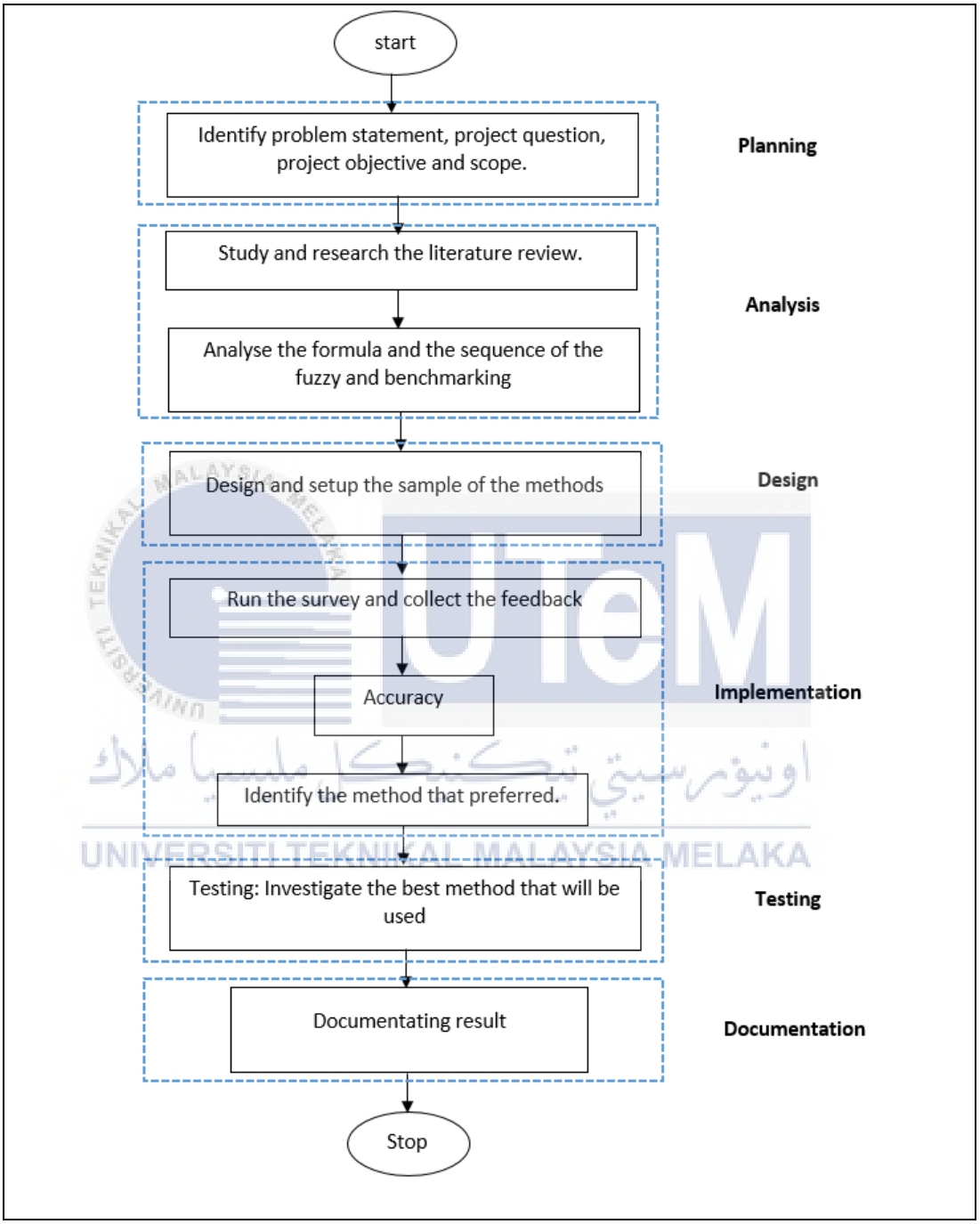

Figure 3.3.1-1 The overall flowchart of the project

3.3.2 Project Milestones

Table 3.3.1 The timeframe of the task in this project

Refer to Section Appendix B.

3.3.3 Gantt Chart of Project

Refer to Section Appendix F.

3.4 Conclusion

In conclusion, in assessing the feasibility of a project, technique plays a critical role. It helps to represent the whole process involved in achieving the objectives. In this section, all of the stages are discussed along with their respective approaches and methods. Both approaches and methods have a strong focus on the main objective of this project to build and quantify a benchmarking model for a decision-making tool. In the next chapter, the established methodology and procedures extracted from this chapter will be discussed further. The next chapter will describe in-depth the basic process and stages of creating a TRIZ Benchmarking Tool Feasibility as A Decision-Making Algorithm.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will cover the whole project, from start to finish, as well as the outcomes. In addition, this chapter, it will address proposing a way to generate the result and analyzing the outcome to see if it would outperform or not. Also, we will analyze a comparison between the suggested approach and the benchmark based on the results collected throughout the experiment.

4.2 The Respondents of the survey

As this research is focused on the students, 90 respondents answered this survey. Below is the summary of survey questions using Google Forms. The example data had been changed from SUV cars to affordable cars for fresh graduates due to current conditions.

i. For student's information

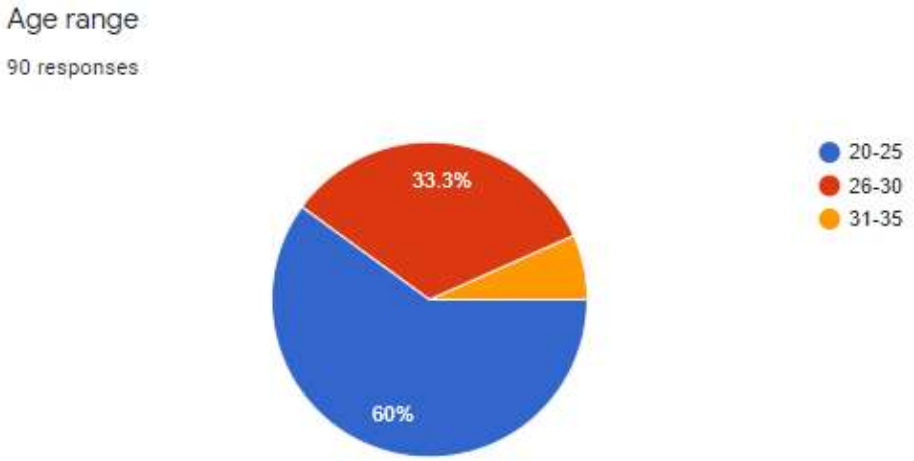

Figure 3.3.3-1 The age range of the respondents.

The highest age range is 20-25 which is 60%. Secondly, age range 26-30 which is 33.3%, and lastly age range 31-35. This percentage shows that most of the students that respond to this survey were in the age range from 20-25.

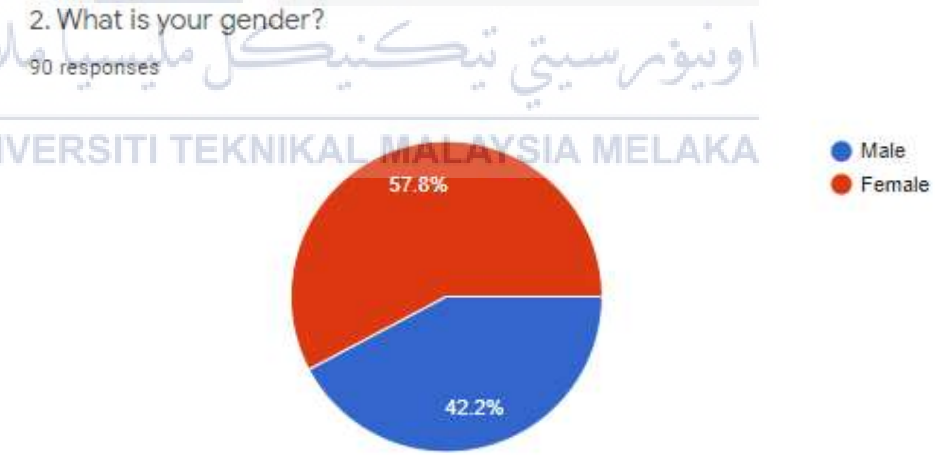

Figure 3.3.3-2 The percentage of gender

The majority of the respondents were 57.8% female while the male was only 42.2%. It shows that female students are more interested to respond in for the survey about buying cars.

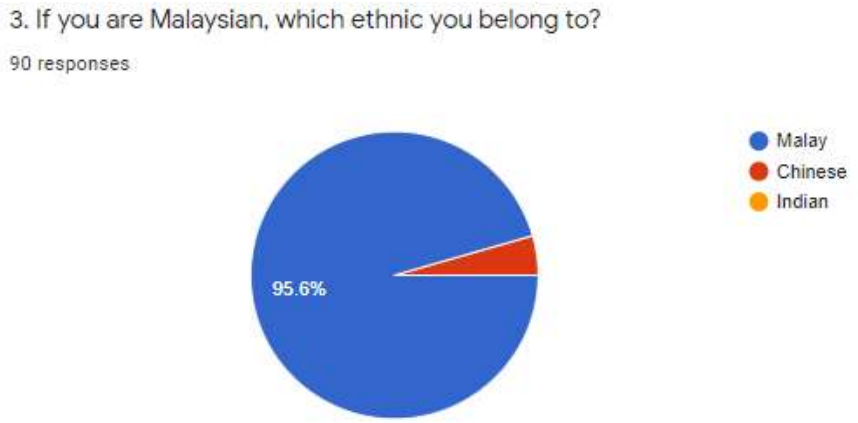

Figure 3.3.3-3 The ethnic of respondents

The majority of the students that answer this survey are Malay which is 95.6%. The rest is Chinese which only 4.4% and there are no Indians that respond to this survey. One of the factors that lead to these percentages includes this survey was distributed only to Malay students and some Chinese students.

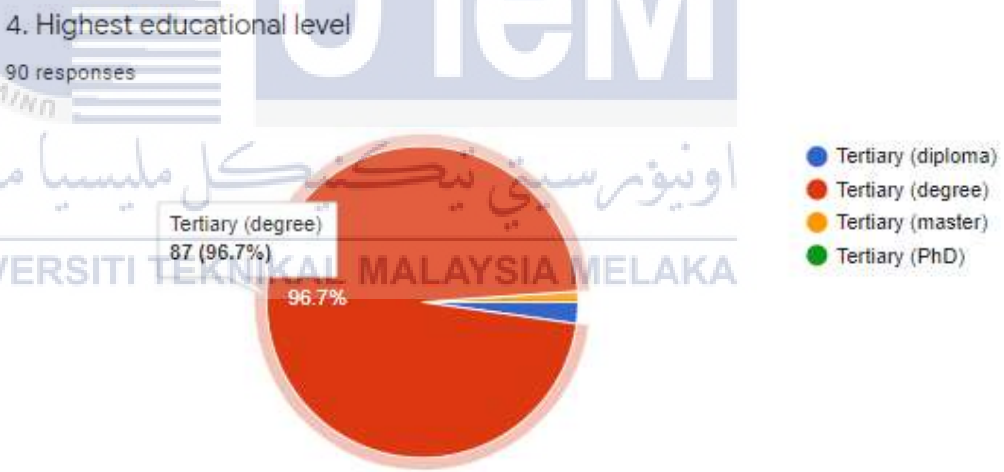

Figure 3.3.3-4 The educational level of respondents

The majority of the students that answer this survey questions have the highest educational level of Tertiary (degree) which is 96.7% of 90 respondents. This means 87 respondents are Tertiary (Degree). The rest 1.1% for Tertiary (master) and 2.2% of Tertiary (diploma).

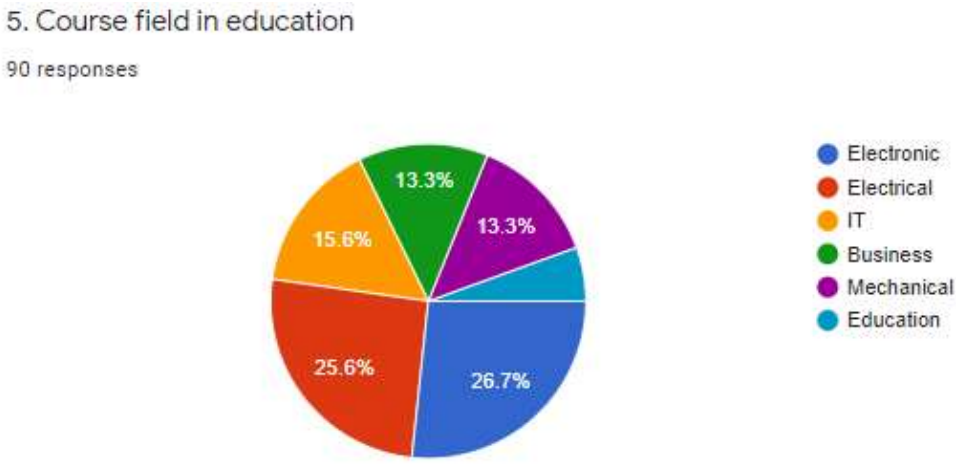

Figure 3.3.3-5 The course field of the respondents

Most respondents are in electronic which are 26.7% and secondly is in electrical which are 25.6%. The rest include IT is 15.6%, Business is 13.3%, Mechanical is 13.3% also and Education is 5.5%. Most of the respondents are from the Electronic and Electric field as this survey was distributed to students from Electronic faculty and Electrical Faculty.

ii. Part for decision making by using the Fuzzy method and the Benchmarking method

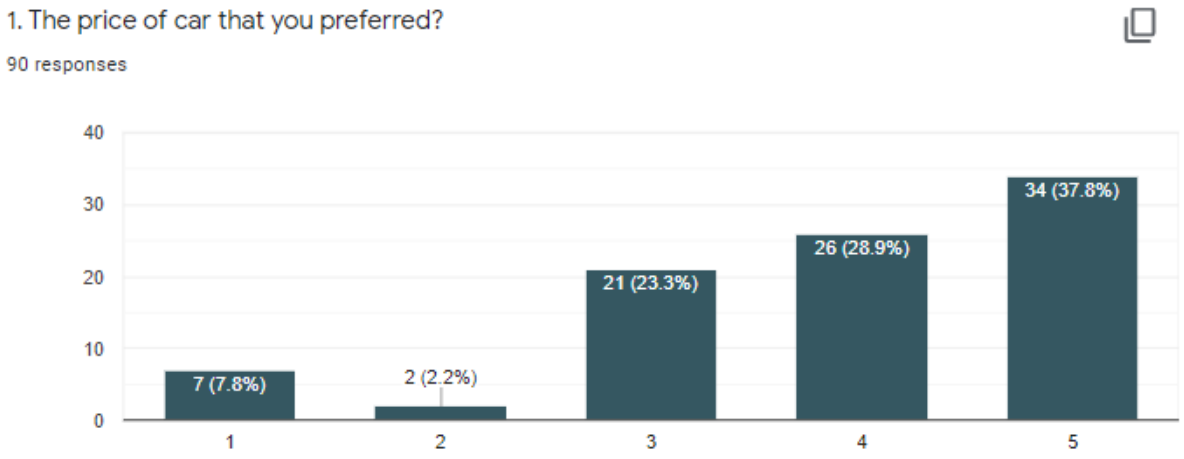

Figure 3.3.3-6 The statistic of the price of the car that preferred

The highest value inserted by the respondents is 5 which is 34 (37.8%). Secondly is value 4 which is 26 (28.9%). Thirdly, value 3 is 21 (23.3%). Fourthly, value 1 is 7 (7.8%), and lastly, value 2 which is 2 (2.2%).

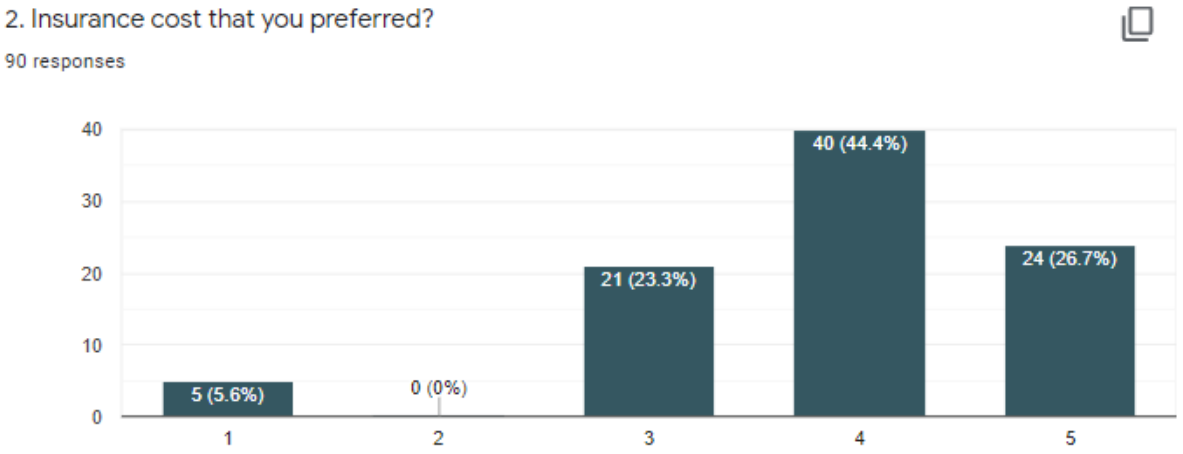

Figure 3.3.3-7 The statistic of insurance cost that preferred

The highest value inserted by the respondents is 4 which is 40 (44.4%). Secondly is value 5 which is 24 (26.7%). Thirdly, value 3 is 21 (23.3%). Fourthly, value 1 which is 5 (5.6%), and lastly, value 2 which is 0 (0%).

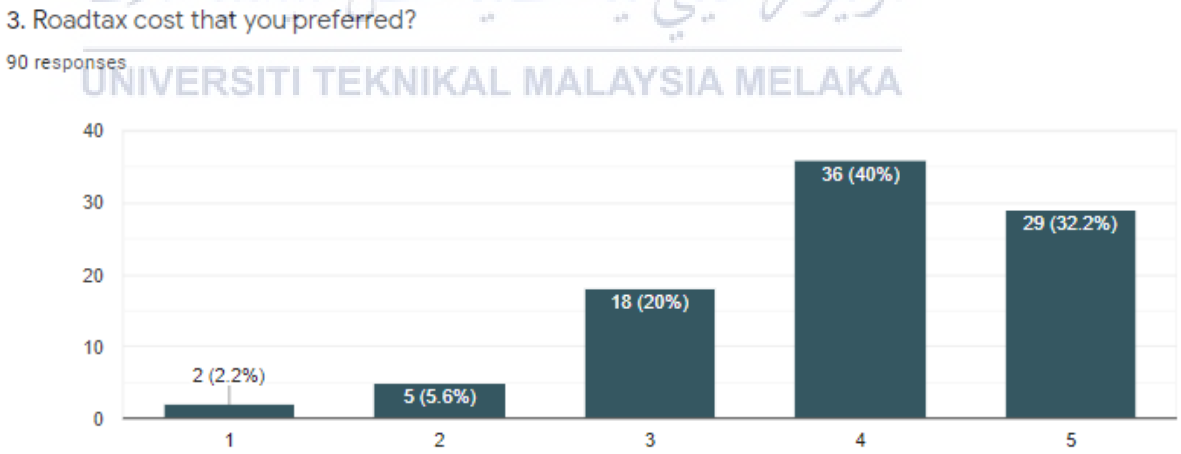

Figure 3.3.3-8 The statistic of road tax cost that preferred

The highest value inserted by the respondents is 4 which is 36 (40%). Secondly is value 5 which is 29 (32.2%). Thirdly, value 3 is 18 (20%). Fourthly, value 2 which is 5 (5.6%), and lastly, value 1 which is 1 (2.2%).

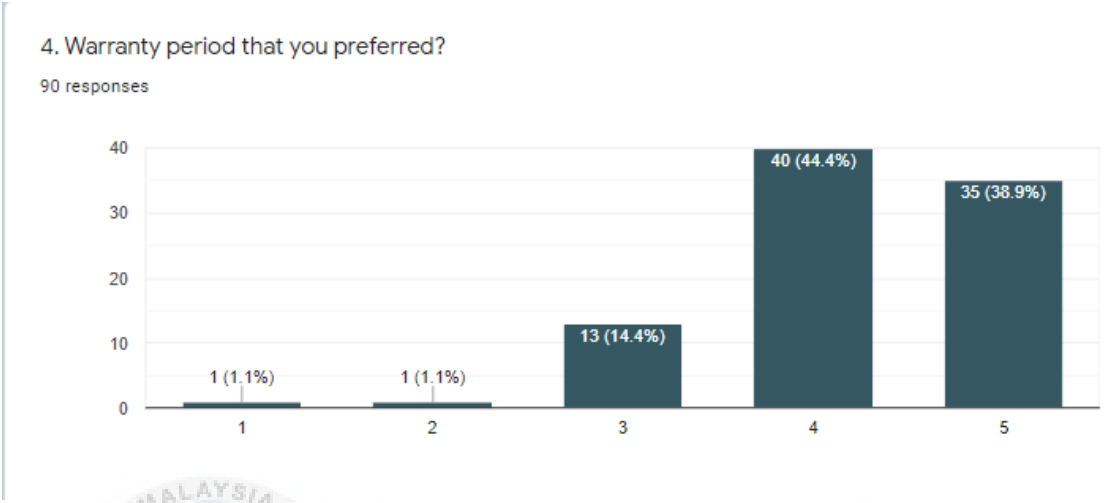

Figure 3.3.3-9 The statistic of warranty period that preferred

The highest value inserted by the respondents is 4 which is 40 (44.4%). Secondly is value 5 which is 35 (38.9%). Thirdly, value 3 is 13 (14.4%). Fourthly, value 1 and value 2 are the same percentage which is 1 (1%).

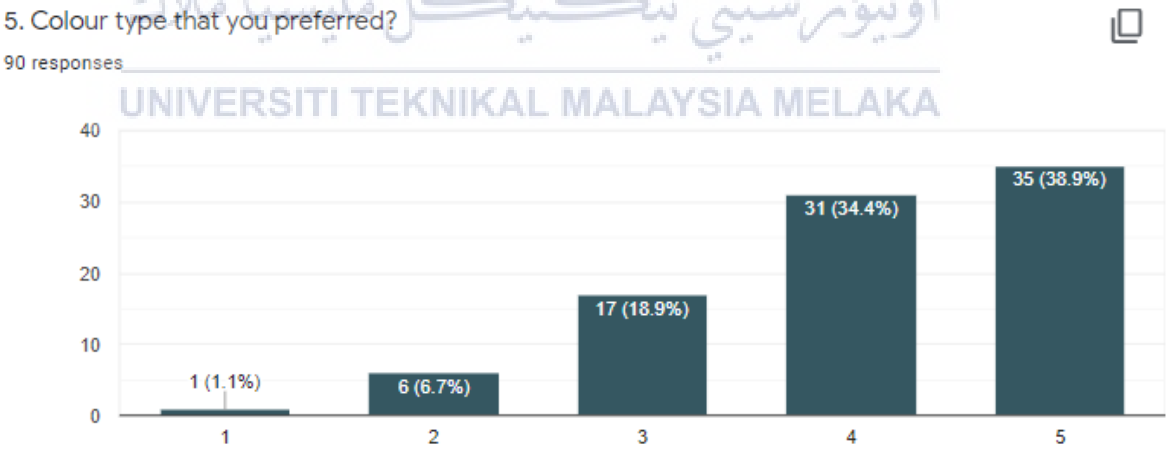

Figure 3.3.3-10 The statistic of the color type that preferred

The highest value inserted by the respondents is 5 which is 35 (38.9%). Secondly is value 4 which is 31 (34.4%). Thirdly, value 3 is 17 (18.9%). Fourthly, value 2 which is 6 (6.7%), and lastly, value 1 which is 1 (1.1%).

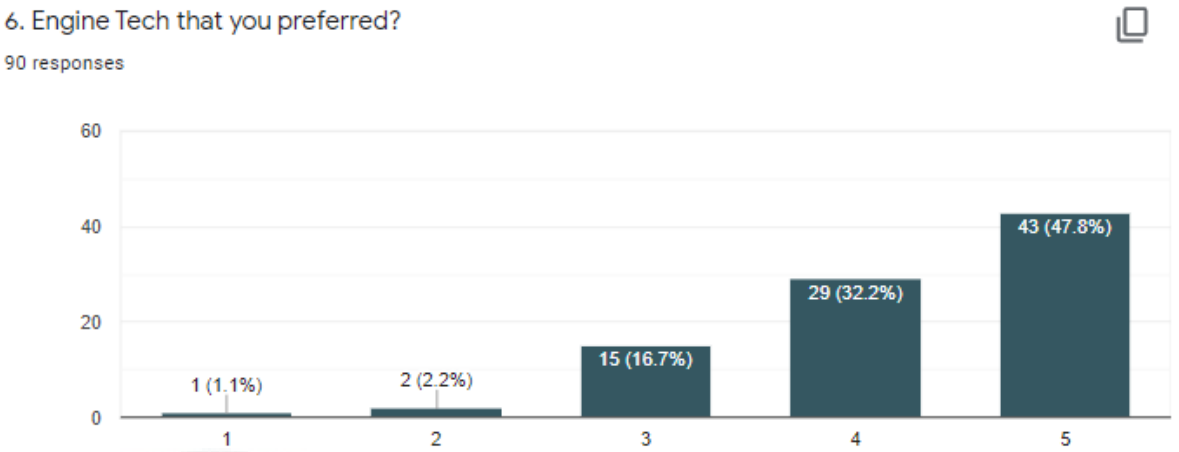

Figure 3.3.3-11 The statistic of engine tech that preferred

The highest value inserted by the respondents is 5 which is 43 (47.8%). Secondly is value 4 which is 29 (32.2%). Thirdly, value 3 is 15 (16.7%). Fourthly, value 2 which is 2 (2.2%), and lastly, value 1 which is 1 (1.1%).

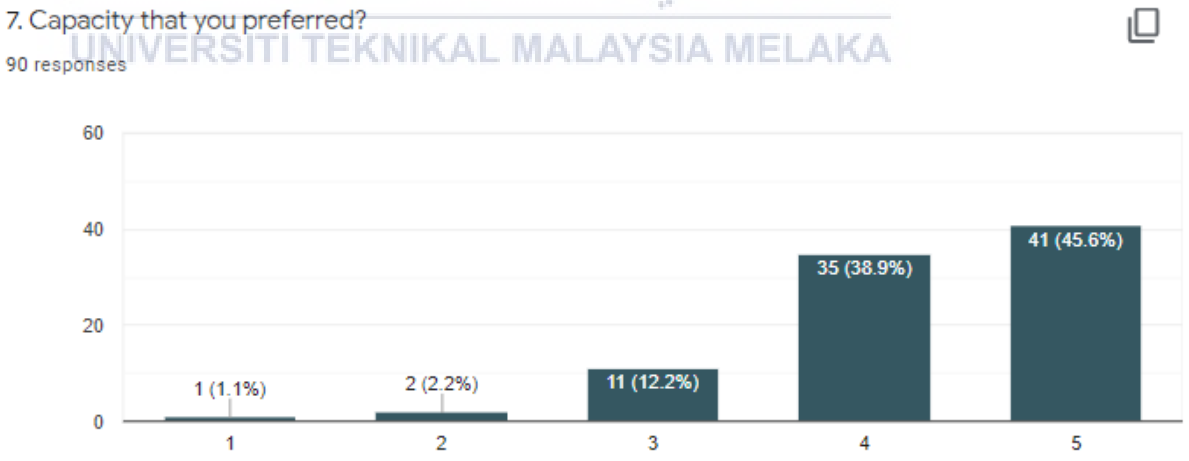

Figure 3.3.3-12 The statistic of the capacity of car that preferred

The highest value inserted by the respondents is 5 which is 41 (45.6%). Secondly is value 4 which is 35 (38.9%). Thirdly, value 3 is 11 (12.2%). Fourthly, value 2 which is 2 (2.2%), and lastly, value 1 which is 1 (1.1%).

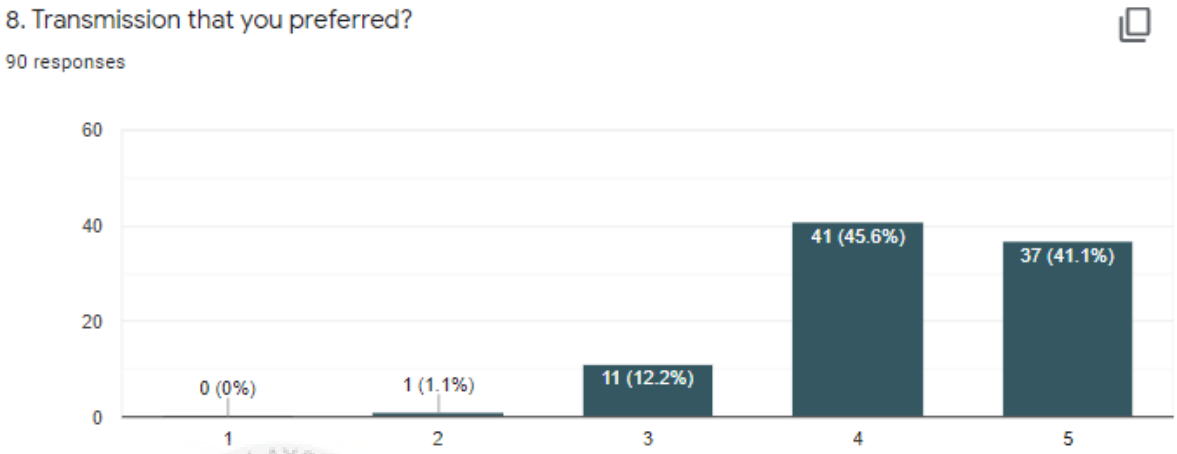

Figure 3.3.3-13 The statistic of transmission of car that preferred

The highest value inserted by the respondents is 4 which is 41 (45.6%). Secondly is value 5 which is 37 (41.1%). Thirdly, value 3 is 11 (12.2%). Fourthly, value 2 which is 1 (1.1%) and lastly, value 1 which is 0 (0%).

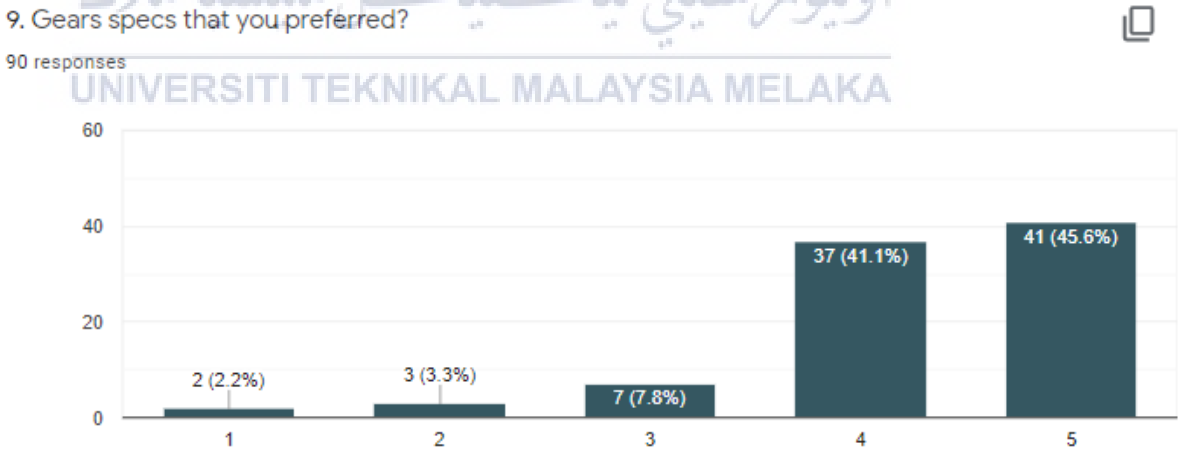

Figure 3.3.3-14 The statistic of Gears spec of car that preferred

The highest value inserted by the respondents is 5 which is 41 (45.6%). Secondly is value 4 which is 37 (41.1%). Thirdly, value 3 is 7 (7.8%). Fourthly, value 2 which is 3 (3.3%), and lastly, value 1 which is 2 (2.2%).

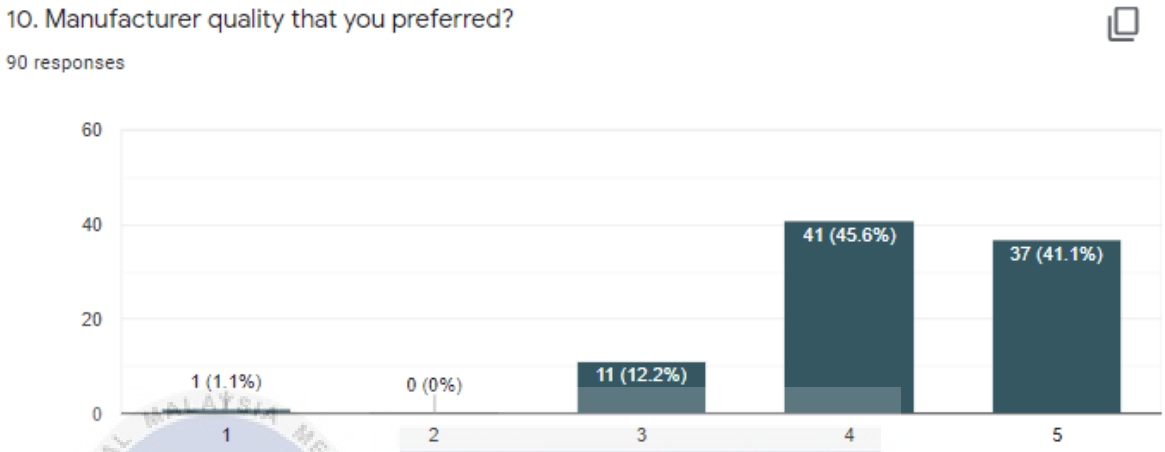

Figure 3.3.3-15 The statistic of manufacturer quality of the car that preferred

The highest value inserted by the respondents is 4 which is 41 (45.6%). Secondly is value 5 which is 37 (41.1%). Thirdly, value 3 is 11 (12.2%). Fourthly, value 1 which is 1 (1.1%) and lastly, value 2 which is 0 (0%).

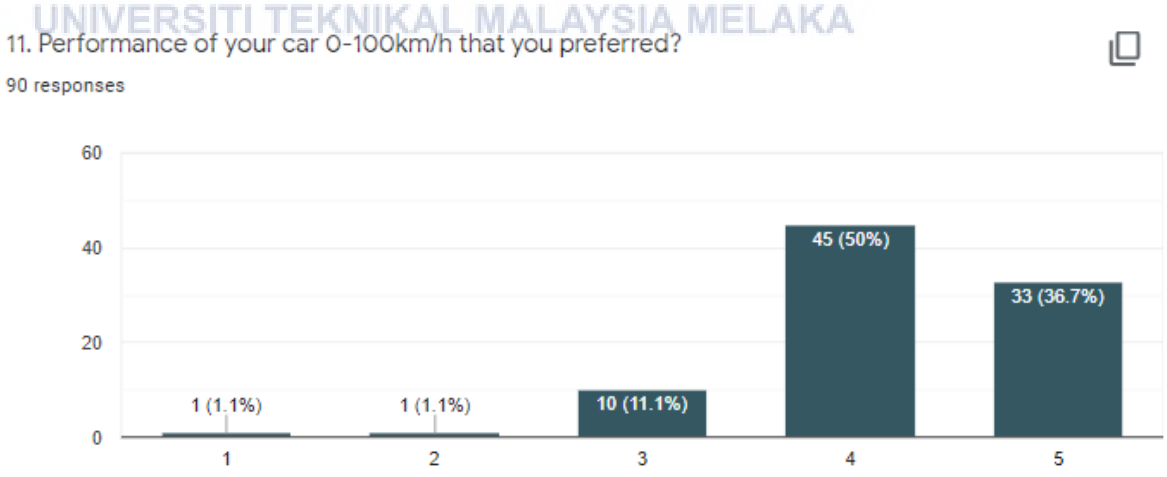

Figure 3.3.3-16 The statistic of performance of the car that preferred

The highest value inserted by the respondents is 4 which is 45 (50%). Secondly is value 5 which is 33 (36.7%). Thirdly, value 3 is 10 (11.1%). Fourthly, value 1 and value 2 are the same percentage which is 1 (1.1%).

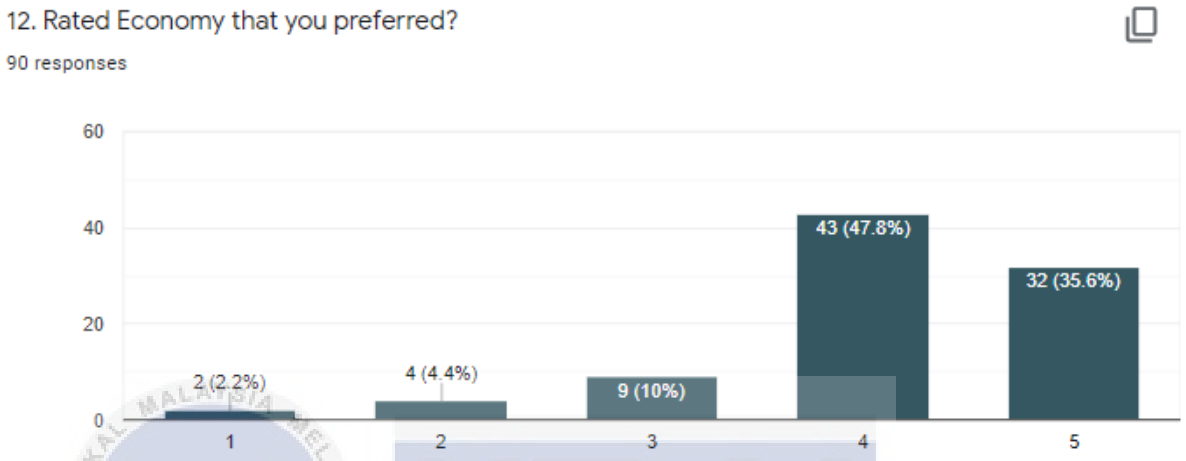

Figure 3.3.3-17 The statistic of the rated economy that preferred

The highest value inserted by the respondents is 4 which is 43 (47.8%). Secondly is value 5 which is 32 (35.6%). Thirdly, value 3 which is 9 (10%). Fourthly, value 2 which is 4 (4.4%), and lastly, value 1 which is 2 (2.2%).

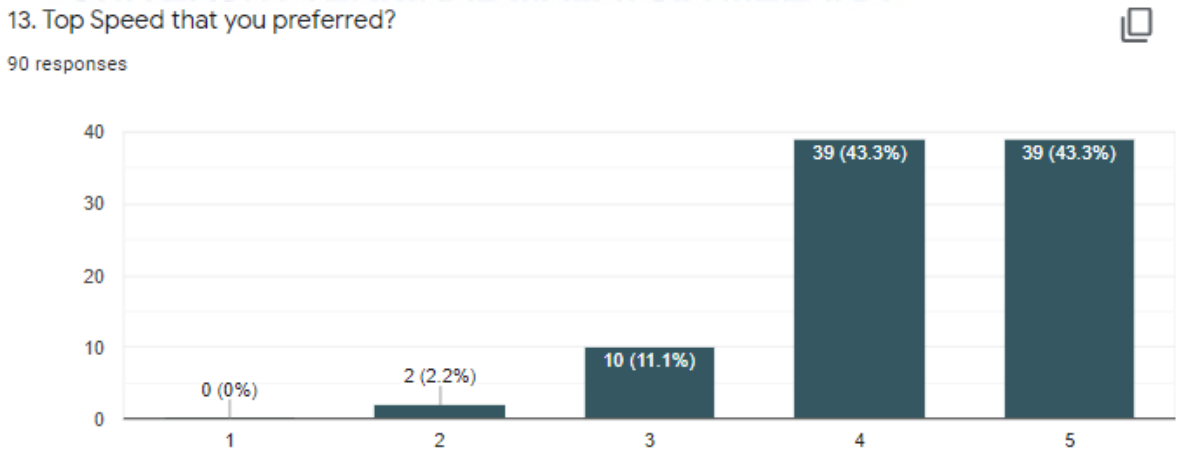

Figure 3.3.3-18 The statistic of a top speed of the car that preferred

The highest value inserted by the respondents is 4 and 5 which is 39 (43.3%). Thirdly, value 3 is 10 (11.1%). Fourthly, value 2 which is 2 (2.2%) and lastly, value 1 which is 0 (0%).

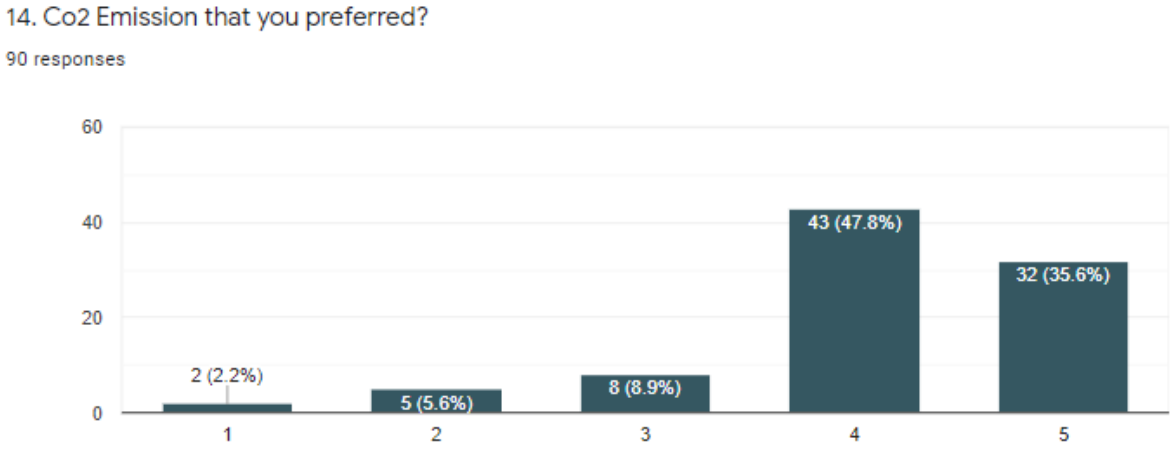

Figure 3.3.3-19 The statistic of Co2 emission that preferred

The highest value inserted by the respondents is 4 which is 43 (47.8%). Secondly is value 5 which is 32 (35.6%). Thirdly, value 3 is 8 (8.9%). Fourthly, value 2 which is 5 (5.6%), and lastly, value 1 which is 2 (2.2%).

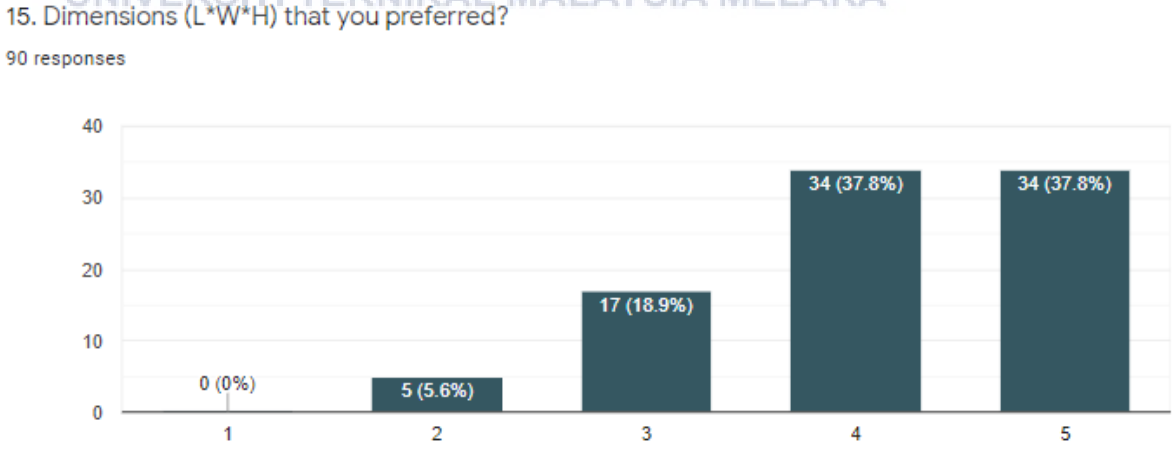

Figure 3.3.3-20 The statistic dimensions of car that preferred

The highest value inserted by the respondents is 4 and 5 which is 34 (37.8%). Thirdly, value 3 is 17 (18.9%). Fourthly, value 2 which is 5 (5.6%), and lastly, value 1 which is 0 (0%).

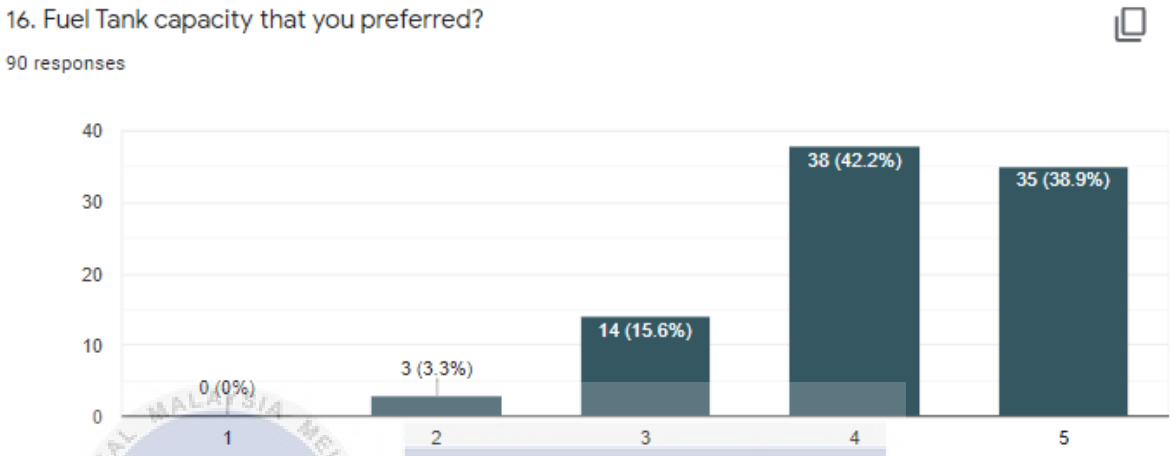

Figure 3.3.3-21 The statistic of fuel tank capacity that preferred

The highest value inserted by the respondents is 4 which is 38 (42.2%). Secondly is value 5 which is 35 (38.9%). Thirdly, value 3 is 14 (15.6%). Fourthly, value 2 which is 3 (3.3%) and lastly, value 1 which is 0 (0%).

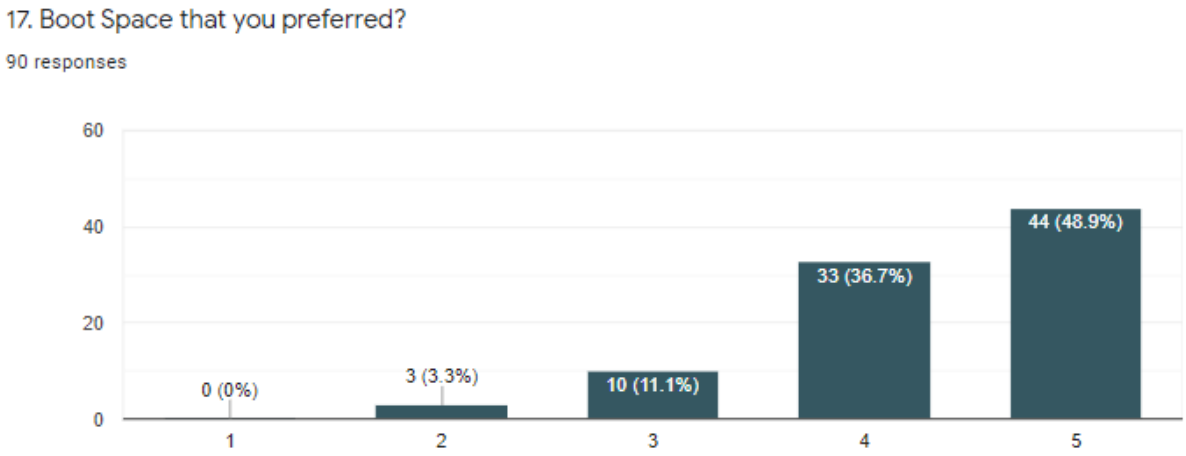

Figure 3.3.3-22 The statistic of boot space of car that preferred

The highest value inserted by the respondents is 5 which is 44 (48.9%). Secondly is value 4 which is 33 (36.7%). Thirdly, value 3 is 10 (11.1%). Fourthly, value 2 which is 3 (3.3%) and lastly, value 1 which is 0 (0%).

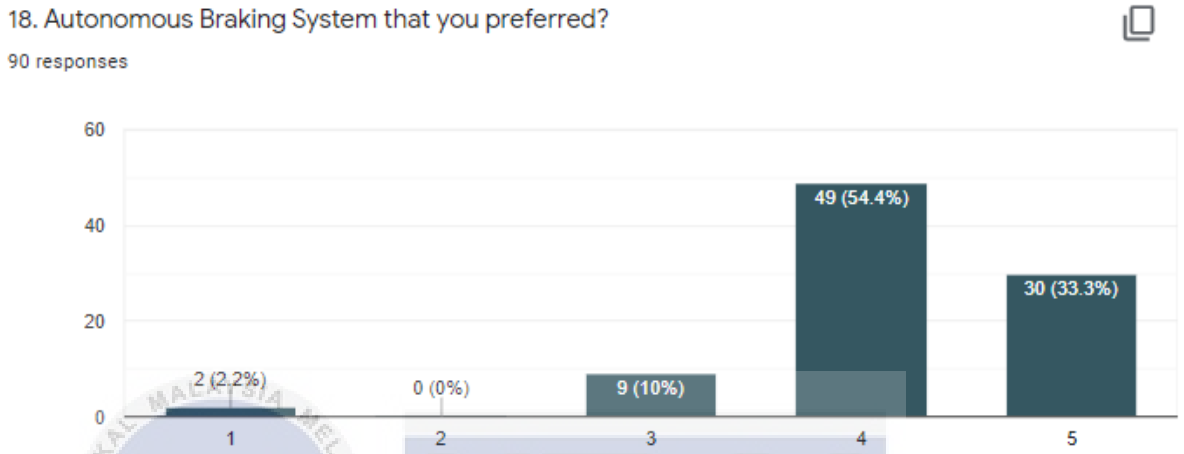

Figure 3.3.3-23 The statistic of autonomous braking system that preferred

The highest value inserted by the respondents is 4 which is 49 (54.4%). Secondly is value 5 which is 30 (33.3%). Thirdly, value 3 which is 9 (10%). Fourthly, value 1 which is 2 (2.2%) and lastly, value 2 which is 0 (0%).

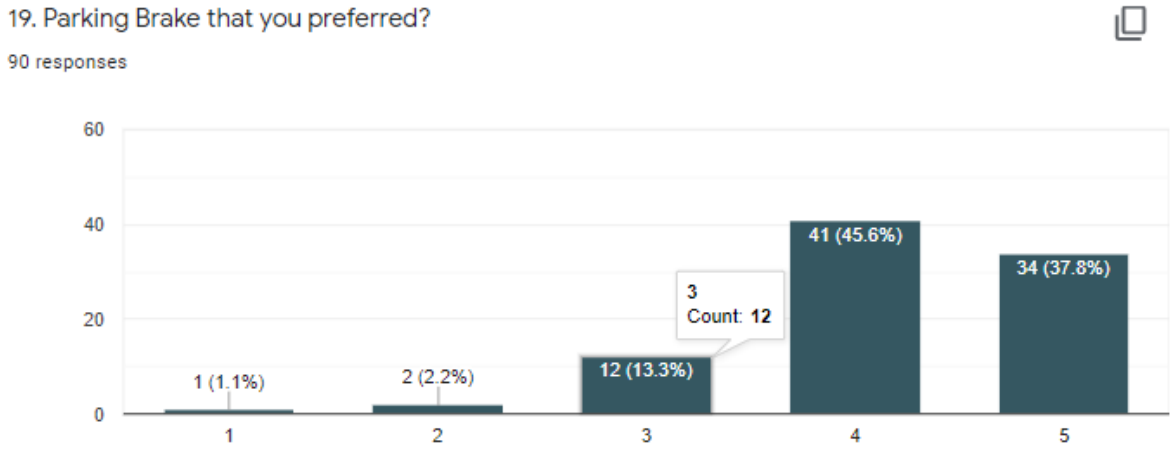

Figure 3.3.3-24 The statistic of parking brake of car that preferred

The highest value inserted by the respondents is 4 which is 41 (45.6%). Secondly is value 5 which is 34 (37.8%). Thirdly, value 3 is 12 (13.3%). Fourthly, value 2 which is 2 (2.2%), and lastly, value 1 which is 1 (1.1%).

iii. Selecting the best method between The Fuzzy method and The Benchmarking method

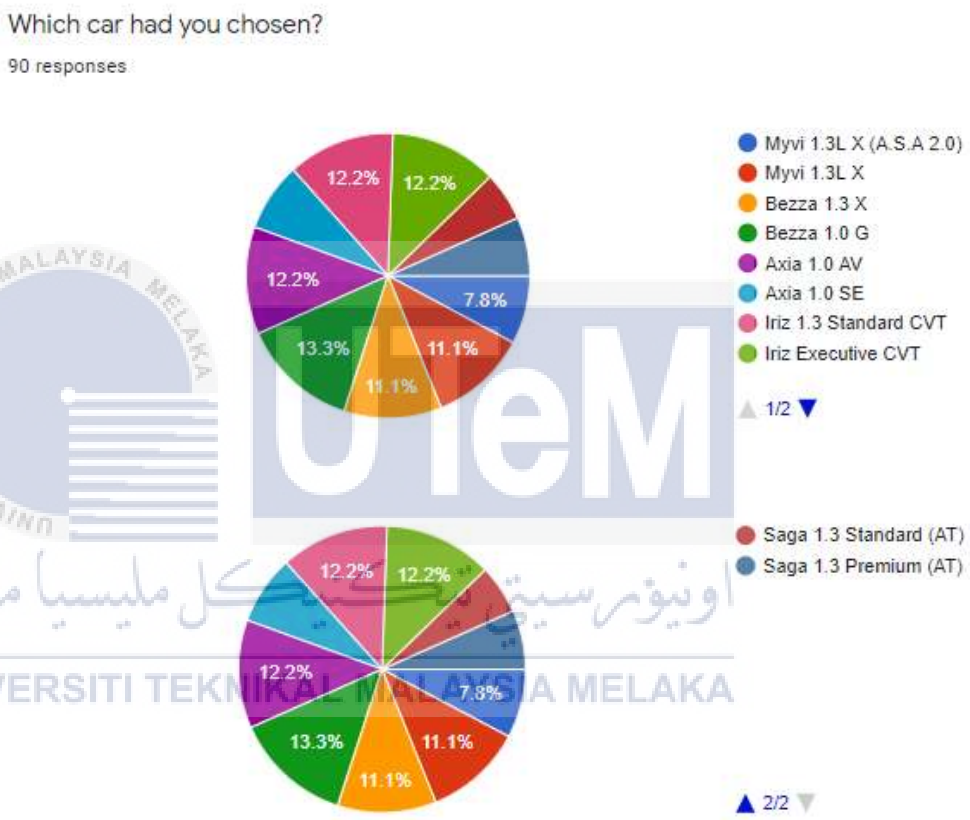

Figure 3.3.3-25 a pie chart of cars chosen by the respondents

From this pie chart, we can see that all the cars selected have an average percentage. The highest percentage is Bezza 1.0 G which is 13.3% and the lowest is Saga 1.3 Standard (AT) which is 5.6%. This means the output of the formula of the method shows the accurate answer where it does not focus on the same car where it would be an error in these two methods.

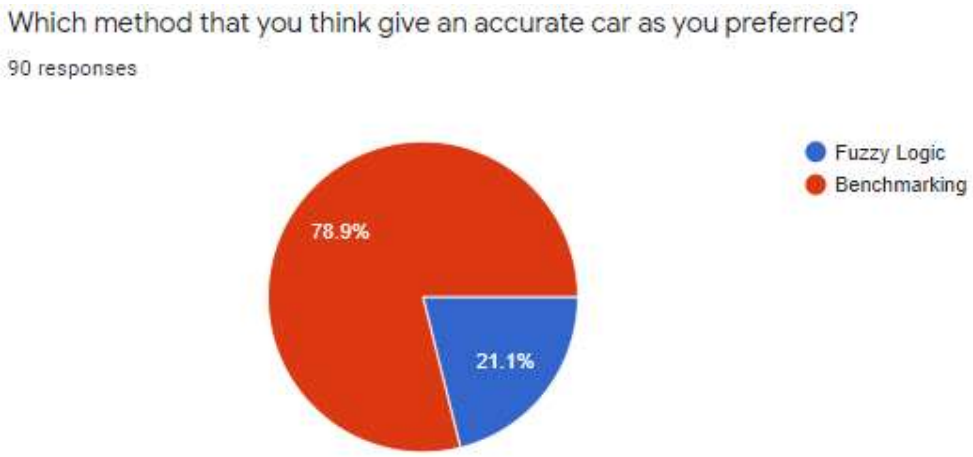

Figure 3.3.3-26 The preference for two methods

From the figure, we can see that 78.9% of the respondents think the same way as the best method for choosing a car is the Benchmarking method. While 21.1% of the respondents think that Fuzzy logic is the best method as they are much satisfied with the answer given by this method.

Figure 3.3.3-27 The pie chart of respondents' satisfaction

95.6% percent of the respondents respond 'Yes' while the rest is responding 'No'. This is because the majority of the respondents are satisfying with the formula of the Fuzzy method and the benchmarking method.

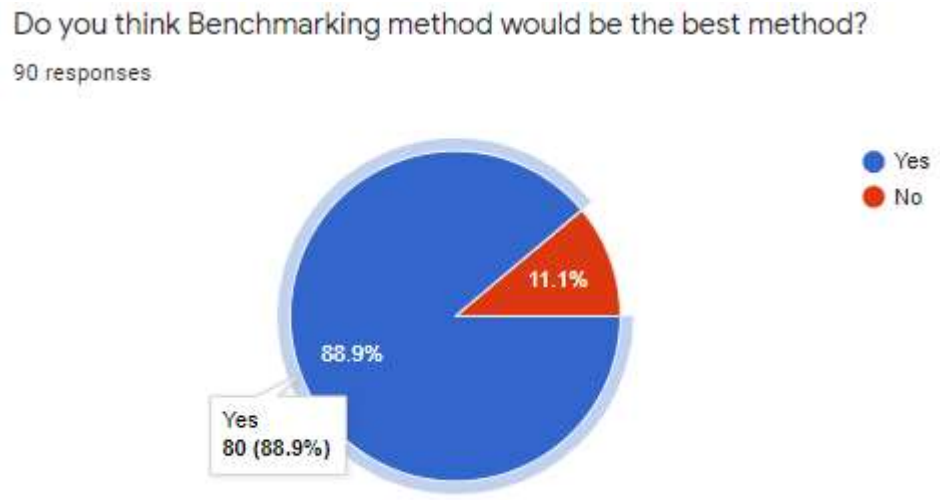

Figure 3.3.3-28 The pie chart of respondents' method choice

After choosing which method is the best solution method as a problem solving to choosing cars, students as a respondent also have to give factors of choosing one of the methods. This will give the strength of the method to be prolonged and continue the project for future works. There were 90 respondents and many of them think that Benchmarking method is a good method as 88.9% chose it.

Table 4.2.1 The table that shows the email of the respondents and the factors of satisfaction

Refer to Section Appendix A.

Based on the table stated above, 90 respondents respond to this survey. By answering all questions, most of them were satisfied with benchmarking methods. It is shown as there are 85 respondents (94.4%) were think that benchmarking method will be the best method for a problem-solving solution. Also, every one of them gives a factor based on their choice. As 85 respondents respond 'Yes' to the question 'Do you think the benchmarking would be the best method?', only 4 respondents did not give feedback about the factor that leads them to choose to benchmark. The rest of 81

respondents gives positive factor feedback. Most of them said that benchmarking method gives an accurate answer.

However, there are 5 respondents (5.6%) that not agreed that benchmarking would be the best method. They also give factors that it is lack of customer satisfaction. This proves that this research needs future work that would improve the system of these two methods.

4.3 GUI by using MATLAB

Based on the table of the email of the respondents and the factors of satisfaction as stated above, 90 respondents respond to this survey. By answering all questions, most of them were satisfied with benchmarking methods. It is shown as there are 85 Since the survey result is showing benchmarking as the best method among the two methods, we decided to choose to benchmark as the decision-making algorithm. Moreover, based on the previous study, it shows that between these two methods (fuzzy logic and benchmark), the benchmarking method is one of the problem solving that showing the positive output. By that, the application of the benchmarking algorithm was developed.

Figure 3.3.3-1 the MATLAB logo

Millions of engineers and scientists use MATLAB to analyze data, develop algorithms, and build models.

MATLAB is a desktop environment that is optimized for iterative analysis and design methods, as well as a programming language that specifically expresses matrix and array mathematics. It comes with the Live Editor, which allows you to write scripts that combine code, output, and structured text into an executable notebook. [19]

Graphical user interfaces (GUIs), also known as apps, allow you to manipulate your software applications through a point-and-click interface, removing the need for others to learn a language or type commands to use it. Apps can be shared for use in MATLAB as well as standalone desktop or mobile apps. [18]

In this part, GUIs is used to help user to choose data. In these GUIs, the user can select the cars by inserting the capping value from 1 to 5 into the column and then press the ‘Done’ button when all the data insertion is done. Then the GUIs system will calculate the data and the answer will pop out.

4.3.1 The interface of GUIs

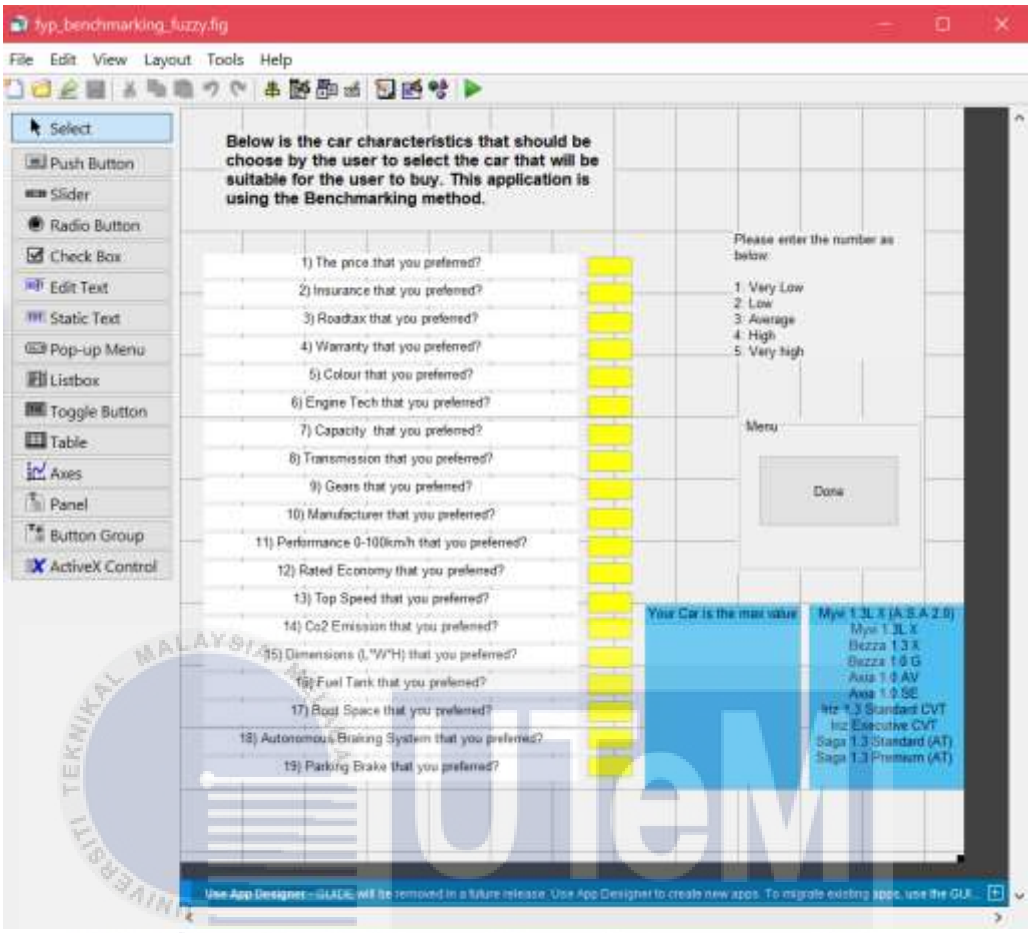

Figure 4.3.1-1 the interface of the GUI

This interface of GUIs by using MATLAB is the application of the interface that is used in excel for the methods formula. All the push-button and static text were set. All of them have their string name that is used in the coding. The string name is used for the function such as the ‘callback’ function. [20]

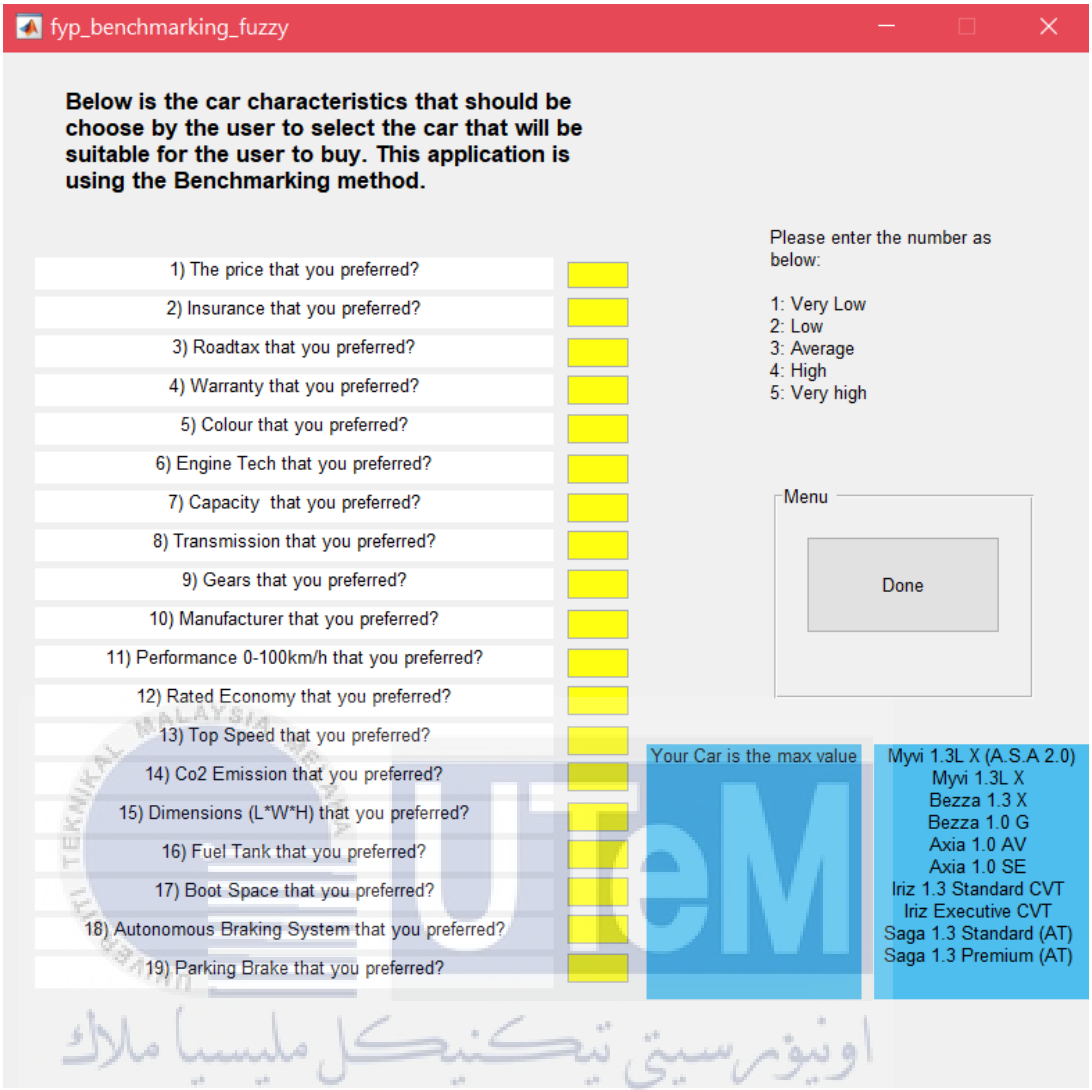

Figure 4.3.1-2 The user interface

This is the interface where the user will fill the weight value 1 to 5 in the blank box (yellow box) and the result will pop out in the left blue box. The blue box will show the answer for this problem-solving method by display the value, and the user would see the maximum value as it is the best choice. The reason for displaying all the value is just because this GUI would also show the user the minimum value of cars that are not suitable for them to buy.

4.3.2 The MATLAB Coding of the GUIs

Coding used the formula for the calculations that perform behind the GUIs. The a,b,c,d,e,f,g,h,I,j,k,l,m,n,o,p,q,r, and s represent the input that will be inserted. All the value that times with a,b,c,d,e,f,g,h,I,j,k,l,m,n,o,p,q,r, and s is calculated from the table in excel as shown in the chapter 3 (methodology).

4.4 Result

This study executes into GUIs and the output is shown in the figure below. There are 5 times data testing by inserting any value from 1 to 5 as the weight value. In these GUIs, the user will:

1. Firstly, insert the number 1 to 5 into the yellow box based on the criteria that mentioned in the questions.
2. Secondly, click done after finish inserting value to all the criteria.
3. Thirdly, in the blue boxes, the values of cars would pop out. The left-blue box shows values, the maximum value shown in the box is resulting in the best car for the user.
4. Fourthly, other values are the reference value for the user to see the second maximum value of the car, the third maximum value of the car, and so on.

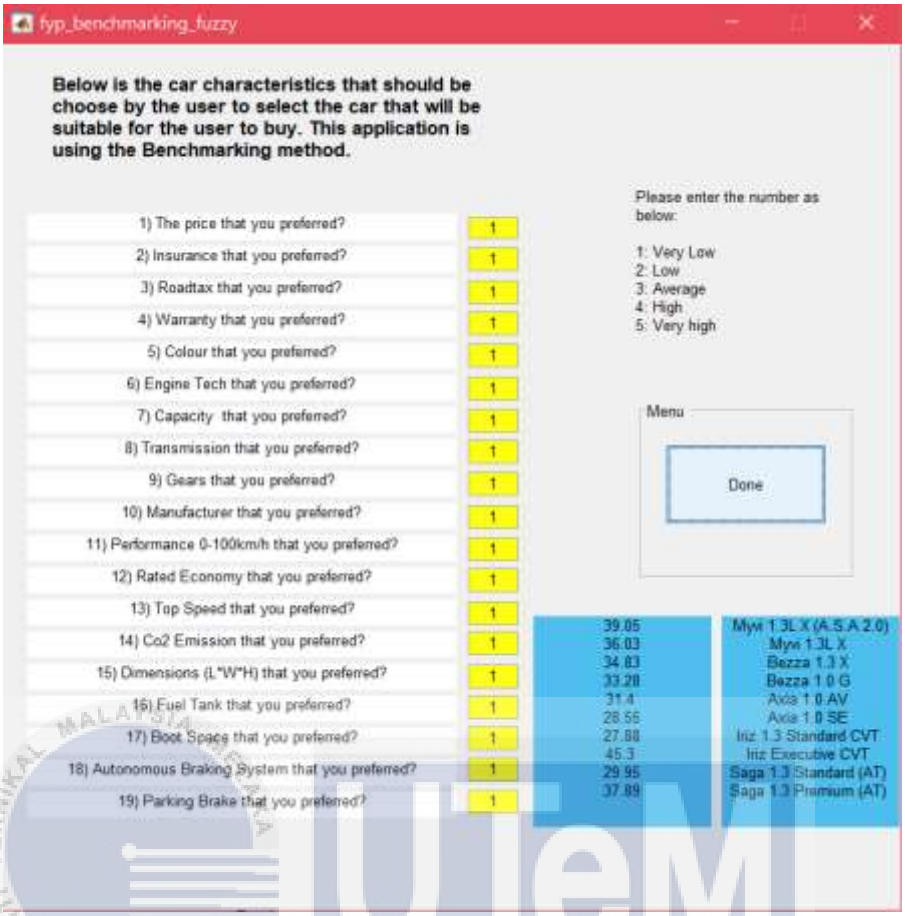

Figure 4.3.2-1 testing GUI benchmarking 1

In this first test of GUIs, the output in the blue box shows Iriz Executive CVT got the maximum value which is 45.3. This is the best car based on the capping values inserted. Secondly is 39.05 which is Myvi 1.3L X (A.S.A 2.0). This is the second-best car for the user. The next value will be the third till tenth car that best for the user. They are Saga 1.3 Premium (AT), Myvi 1.3L X, Bezza 1.3X, Bezza 1.0G, Axia 1.0 AV, Saga 1.3 Standard Premium, Axia 1.0 SE, and lastly Iriz 1.3 Standard CVT.

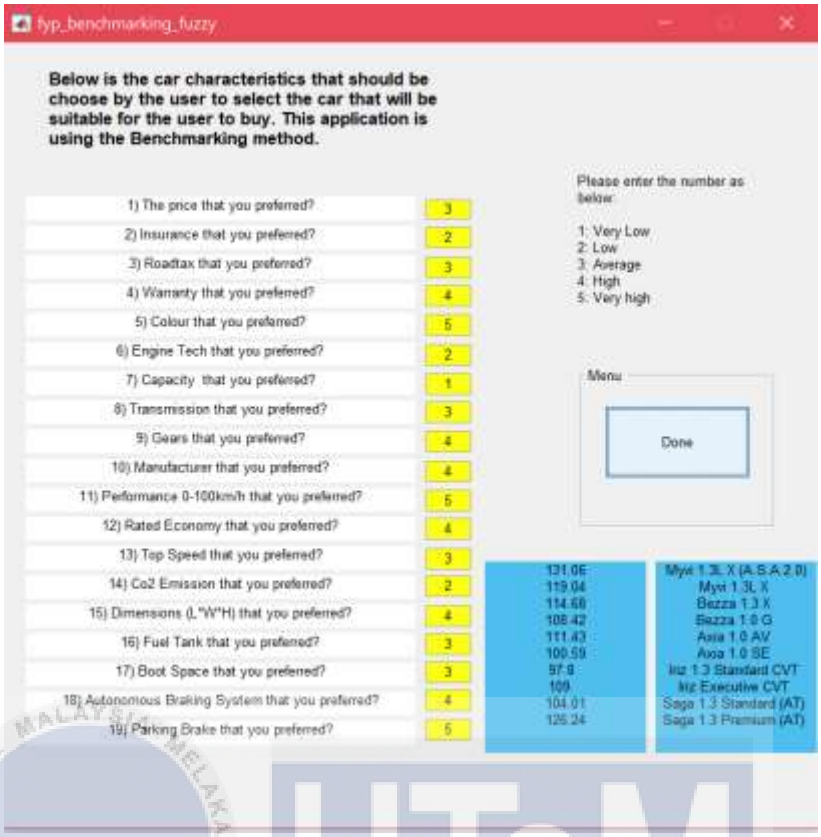

Figure 4.3.2-2 testing GUI benchmarking 2

This the second test of GUIs. It comes with Myvi 1.3L X (A.S.A 2.0) which has the highest value of 131.06. The next maximum value is Saga 1.3 Premium (AT) with a value of 126.24. The rest value is the reference for the user to look.

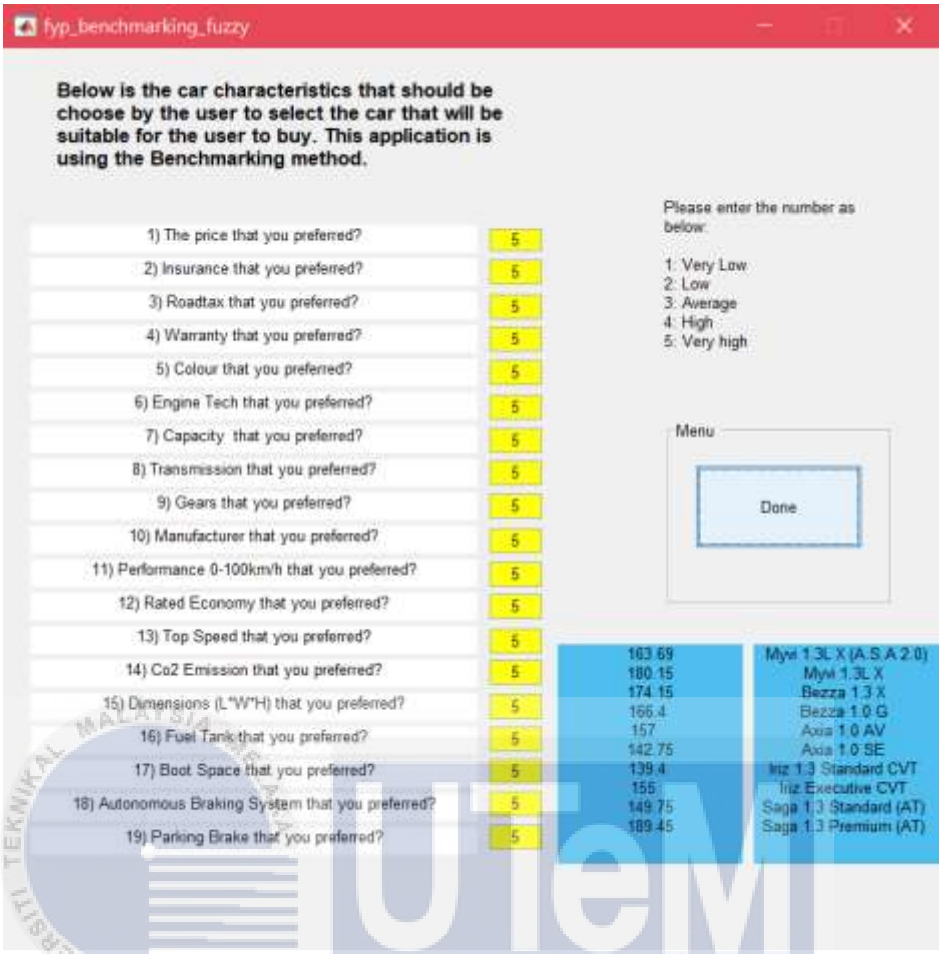

Figure 4.3.2-3 testing GUI benchmarking 3

This the third test of GUIs. It comes with Saga 1.3 Premium (AT) which has the highest value of 189.45. The next maximum value is Myvi 1.3L with the value 180.15. The rest value is the reference for the user to look

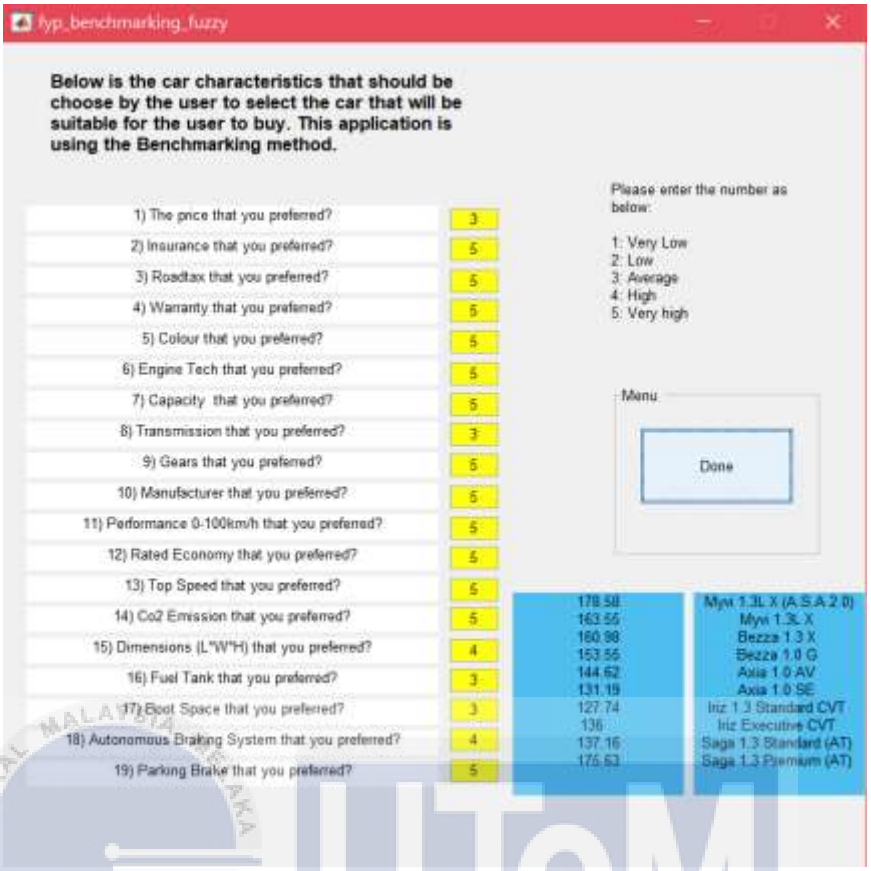

Figure 4.3.2-4 testing GUI benchmarking 4

This the fourth test of GUIs. It comes with Myvi 1.3L X (A.S.A 2.0) which has the highest value 178.58. The next maximum value is Saga 1.3 Premium (AT) with a value of 175.63. The rest value is the reference for the user to look.

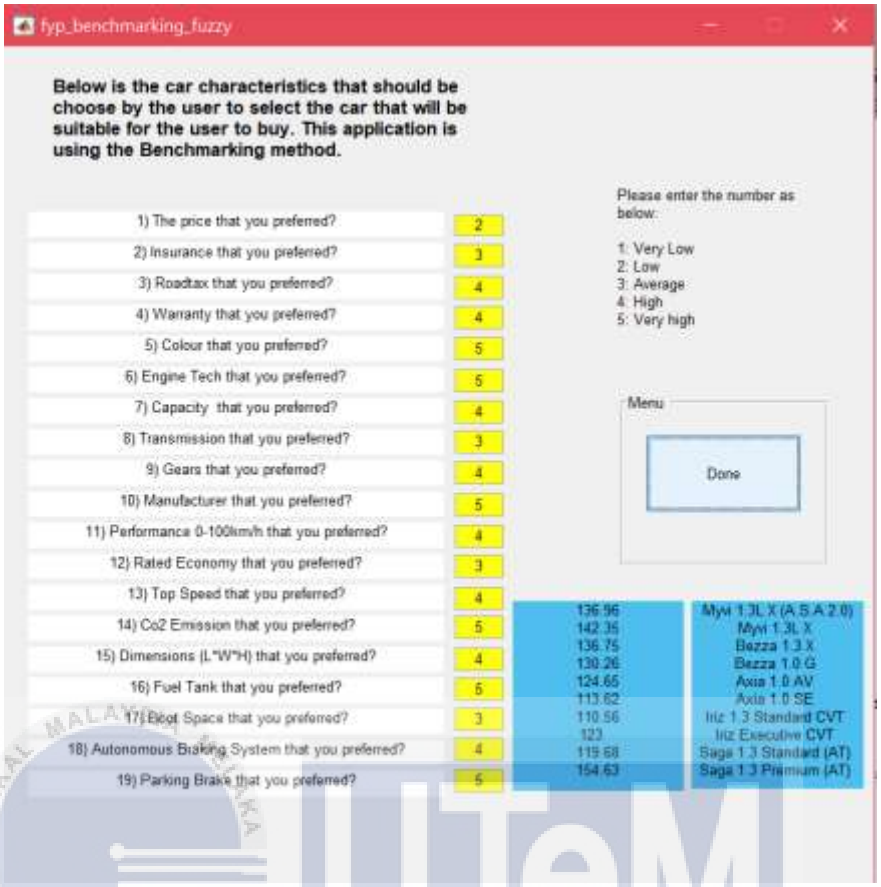

Figure 4.3.2-5 testing GUI benchmarking 5

This the fourth test of GUIs. It comes with Saga 1.3 Premium (AT) which has the highest value of 154.63. The next maximum value is Myvi 1.3L with a value of 142.35. The rest value is the reference for the user to look.

No.	Output (max)	Cars
1	226.50	Iriz Executive CVT
2	131.06	Myvi 1.3LX (A.S.A 2.0)
3	189.45	Saga 1.3 Premium (AT)
4	178.58	Myvi 1.3L X (A.S.A 2.0)
5	154.63	Saga 1.3 Premium (AT)

Table 4.4.1 The GUIs output test

4.5 Discussion

As there are the majority of the respondents select Benchmarking as the best method with positive factors, the application is based on the GUIs MATLAB developed for the benchmarking method. This is because it would be more interactive and user-friendly as a user need a platform of decision making by using this method easily.

However, several respondents that not satisfied with the benchmarking method agreed that this method is lack customer satisfaction. This would be taken as a factor of future works should be performing to make some improvements.

In the terms of sustainability and design, this project does not consume any non-renewable resources and minimize waste as it is fully simulated by using Matlab software. Also, this project does not use the money to prevent wastage and save costs.

4.6 Conclusion

In conclusion, in assessing the feasibility of a project, the result execution plays a critical role. It helps to represent the whole process involved in achieving the objectives. In this section, all of the stages are finalized along with their respective summarization and methods. Both summarization and methods have a strong focus on the main objective of this project to build and quantify a benchmarking model for a decision-making tool. In the next chapter, the established result and discussion extracted from this chapter will be concluded. The next chapter will wrap all the process, method, result, and discussion of the basic process and stages of creating a TRIZ Benchmarking Tool Feasibility as A Decision-Making Algorithm.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 Introduction

This chapter focuses on compiling a summary of all of the project's results and findings. This final phase is critical for ensuring that the goals are met and discussed. This chapter also will go over how each of the objectives was met and what can be done to improve things in the future. Constraints are also discussed and analyzed because they are the most important factor influencing the project's path.

5.2 Conclusion of Project

A special problem-solving method is indeed required to solve a decision problem that involves many data and classifications. The problems here mean the problem that complicated and not easy to be solved. By that, Benchmarking method and the Fuzzy method are the methods to make a decision that involves many data. In

this project, Benchmarking and Fuzzy Logic methods will be used for decision-making. There is a different algorithm between these two methods. To recognize which method is the best, this study would carry out the elements that will help to analyze the feasibility of the benchmarking model in deciding the optimum car that suitable for the fresh graduate.

To run this project, besides of study from past research papers, a survey using Google forms was distributed to 90 respondents. The respondents are UTeM students. This survey is to compare whether a benchmarking method or fuzzy method would be the best problem-solving method. About 85 of the respondents agreed that benchmarking is the best problem-solving method.

As the benchmarking method is shown as the best method, it is a chance that TRIZ benchmarking could be used as a tool for decision making. A Graphical User Interfaces (GUIs) build. These GUIs are built by using MATLAB software. The execution is tested several times to prove the accuracy. This project does face several constraints in conducting a series of experiments such as it is covid19-time where it is a pandemic and many limitations occur such as university closed, students faced online learning, all the coursework need to be done online and the covid19 cases increasing daily. These problems give a big impact on this study as the output project only could be done by using software for the simulation.

The project's contribution is that it will use the Benchmarking method to select the best pattern of accuracy in problem-solving methods, where the methods are chosen by consumers as having a bright future to assist users as a problem-solving method. Aside from that, using datasets of affordable cars for recent graduates, this study is successfully invalidating. This research project just focuses only on

processing content. Besides that, this project uses the dataset of affordable cars for fresh graduates such as Myvi, Bezza, Axia, and Iriz that not used by many previous types of research. The survey of finding the best method between these two methods is focused on UTeM students. Finally, this project research is implementing the problem-solving method only.

For future work, this project can improve by process all attributes not only limited to methods selection. It is suggested to improve the execution of the project to have a good application for the easy use of users. The execution of the output for GUIs that applied in this project also could be improved by specifying the best car for the consumers. Furthermore, because the training phase is dependent on certain equipment, the project may make use of sophisticated technology.

In a roundabout way, this project was able in meeting all of its goals. However, some future improvements for better use have been highlighted. Any proposed adjustment should always maintain a high level of accuracy when executing the methods. This will aid in ensuring that users always receive the correct answer and make the best decision possible.

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APPENDICES

Appendix A

No.	Email	Do you think Benchmarking method would be the best method?	Based on your previous answer, give factors that make you think that way.
1	fatinaqilah1907@gmail.com	Yes	Easy to refer
2	kysan1087@gmail.com	Yes	I like Benchmarking more
3	fikrisemesti@gmail.com	Yes	-
4	b011710077@student.utem.edu.my	Yes	easy to count
5	syahirah6565@gmail.com	Yes	good performance
6	shazwanianis6490@gmail.com	Yes	Benchmarking is a way of discovering what is the best performance being achieved
7	sitinabilah@gmail.com	Yes	Easy to refer and get the closest answer
8	faizalayob16@gmail.com	Yes	we can know or test the performance by bencmarking
9	idhamzali@gmail.com	Yes	.
10	aliyakhairul040898@gmail.com	Yes	Benchmarking method is easier than fuzzy logic
11	b021710205@student.utem.edu.my	No	Fuzzy logic is much easier compared to benchmarking
12	wanieyizlan31@gmail.com	No	Easy to find the best car
13	nabilahahmad98@gmail.com	Yes	Set performance expectation
14	ainnabila93@gmail.com	Yes	benchmarking practices provide a better understanding of customer wishes and expectations. This is because customers are the most important data source at every stage of comparison.
15	nurzalina98@gmail.com	No	I have no idea but this is compulsory to fill up.
16	zatiyusof96@gmail.com	Yes	-
17	fatinaqilah1907@gmail.com	Yes	Easy to refer
18	kysan1087@gmail.com	Yes	I like Benchmarking more
19	azwar.gpme@gmail.com	Yes	Performance
20	muhammadsyafiqhadi96@gmail.com	No	Lack of customer satisfaction
21	aidil98@gmail.com	Yes	Accurate answer
22	raihanah97@gmail.com	Yes	Suitable car
23	aisyahnabilah97@gmail.com	Yes	Iriz is my fav car
24	haiqalhareeq@gmail.com	Yes	Accurate answer
25	qistinasapri@gmail.com	Yes	I want to buy Axia
26	syahidahnur@gmail.com	Yes	The best answer
27	nuraiman13@gmail.com	Yes	Best answer
28	khairulraziq@gmail.com	No	My favourite car is myvi
29	doranadeera@gmail.com	Yes	Accurate answer so far
30	muhammad@gmail.com	Yes	clear data

No.	Email	Do you think Benchmarking method would be the best method?	Based on your previous answer, give factors that make you think that way.
31	farihahatiqah@gmail.com	Yes	Iriz is a good car
32	alif@gmail.com	Yes	clear data
33	afiq@gmail.com	Yes	easy to count
34	muhammadhairi27@gmail.com	Yes	Saga is a good car suitable with my character
35	ali@gmail.com	Yes	good system
36	b021710164@student.utem.edu.my	Yes	Good & accurate answer
37	ali@gmail.com	Yes	more systematic
38	b021710175@student.utem.edu.my	Yes	The answer give my fav car
39	umar@gmail.com	Yes	accurate data
40	osman@gmail.com	Yes	accurate
41	zalinaakharudin@gmail.com	Yes	Best answer because shows the car that i want
42	affan@gmail.com	Yes	good system
43	aliyakhairul@gmail.com	Yes	Answer shows good car for me
44	fattah@gmail.com	Yes	systematic
45	syafiqazmi17@gmail.com	Yes	Best answer
46	rahmat@gmail.com	Yes	accuraccy
47	amri@gmail.com	Yes	accuracy
48	nurulhaziqah99@gmail.com	Yes	Good car for me
49	ahmadsyamel15@gmail.com	Yes	Good answer
50	ahmadmirza56@gmail.com	Yes	The method giving the best car
51	muhdfarhanisron@gmail.com	Yes	Both method give best answer
52	sitiraihan@gmail.com	Yes	This method give accurate answer which is Axia.
53	intannursyahida10@gmail.com	Yes	Benchmarking method gives a good answer
54	muhammadhxfyzu@gmail.com	Yes	This method gives the good answer
55	hasyimaa138@gmail.com	Yes	Good method as it gives a good answer
56	nurhusnayatim_11@gmail.com	Yes	This methods gives a good car as an answer
57	nuratifahnasha14@gmail.com	Yes	It gives answer the car that suitable for me
58	nursyahidahnuraihan06@gmail.com	Yes	Gives the best answer as i also want this type of car.
59	ainnabilasyukri@gmail.com	No	Fuzzy methods give the answer that i want.
60	nurulhudahisham@gmail.com	Yes	Iriz is my dream car and this method gives acurrate answer based on the characteristics that i give

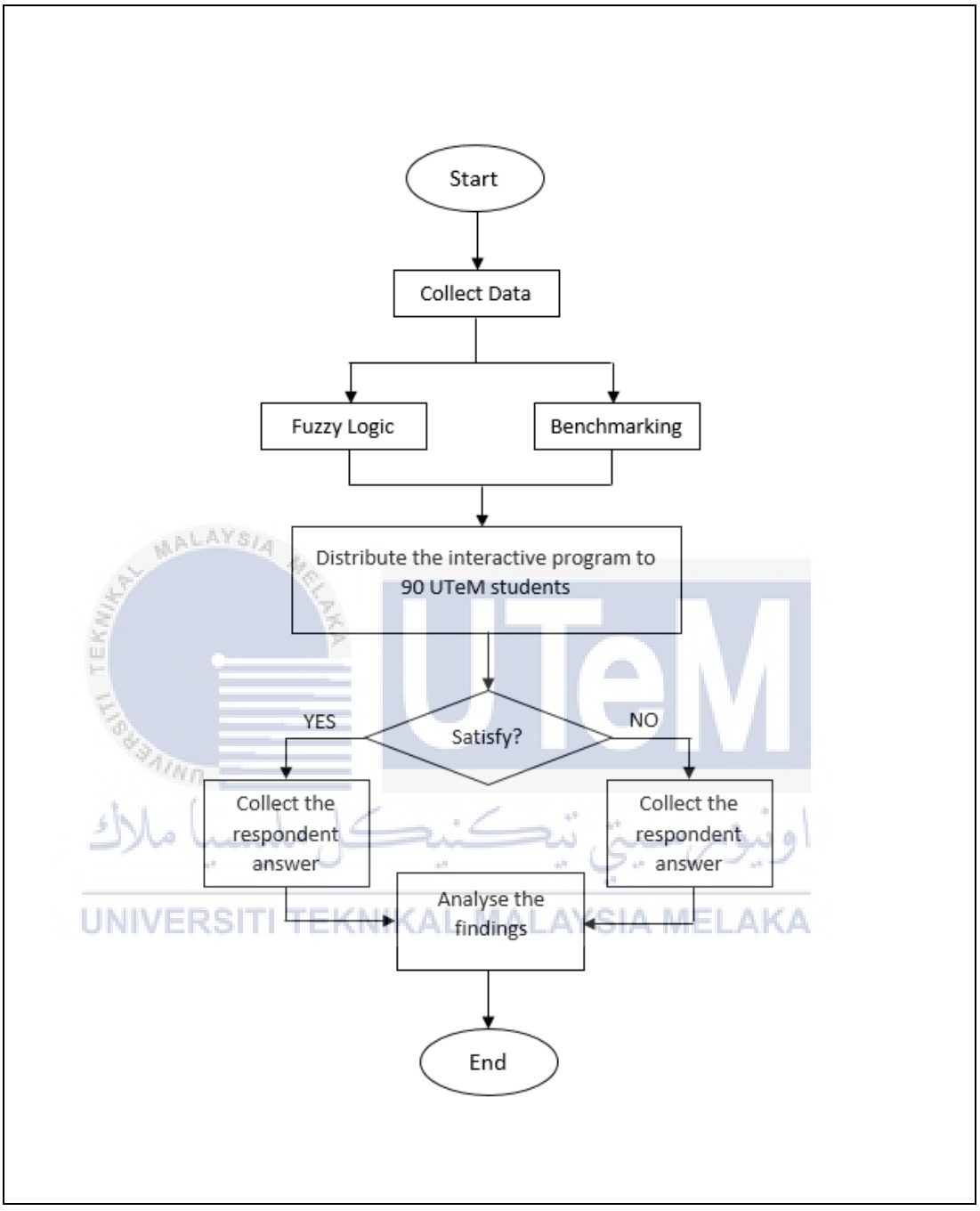
No.	Email	Do you think Benchmarking method would be the best method?	Based on your previous answer, give factors that make you think that way.
61	nurzafirahahmad@gmail.com	Yes	-
62	mimiehatirah26@gmail.com	Yes	Gives me an accurate answer to my characteristic
63	syazaamirazulkeplee@gmail.com	Yes	This method gives me an accurate answer which myvi is my favourite car.
64	farahsyakirah@gmail.com	Yes	This methods give an accurate answer
65	ariffrahim@gmail.com	Yes	Based on these two methods, benchmarking method gives me the best car based on the characteristics.
66	nursyakirah@gmail.com	Yes	It is because benchmarking method gives answer that accurate with my characteristics
67	ahmadaqil0706@gmail.com	Yes	Perodua bezza is my target car after degree and benchmarking method gives it as the answer. So basically this method gives me the accurate answer
68	nursyahirahabdrahim@gmail.com	No	Wrong car. The car that I want is bezza.
69	amirahnasuhabintiadlin@gmail.com	No	I prefer fuzzy logic method as it give me the car that i want as the answer.
70	fatinnabilah1208@gmail.com	Yes	This methods comes with the right answer.
71	amirahsyahirah08@gmail.com	Yes	With some improvements, i thinks this method will give better answer soon.
72	saranatashamohdnasir@gmail.com	No	Fuzzy logic method gives me the better answer.
73	syafiqss@gmail.com	Yes	clear data
74	hakimiii@gmail.com	Yes	good reference
75	azhann12@gmail.com	Yes	give more detail that wanted
76	khairullz23@gmail.com	Yes	easier to refer
77	fikriii17@gmail.com	Yes	good data
78	rashidsideq@gmail.com	Yes	good clarify
79	anwarr22@gmail.com	Yes	good data system
80	amirullz98@gmail.com	Yes	good system
81	kiyingg06@gmail.com	Yes	It is a good method where we can make a decision accurately to choose which car that we should buy.
82	yixuan1715@gmail.com	Yes	I can make a decision precisely
83	mohdnasir02@gmail.com	No	These methods needs more improvements
84	ammarazhan114@gmail.com	Yes	This method give me a nice car as answer
85	sitihajar_yahyaaa@gmail.com	Yes	Benchmarking method gives a suitable car for me
86	farishadnan_@gmail.com	Yes	Good method
87	aleefhazeeqq@gmail.com	Yes	This method is satisfy the characteristics that i want
88	taaliaanissuraya@gmail.com	Yes	Benchmarking shows better answer
89	aisyahfatihahyazid02@gmail.com	Yes	Accurate answer
90	bellaarwanaaa@gmail.com	Yes	This is a good method to make decision

Appendix B

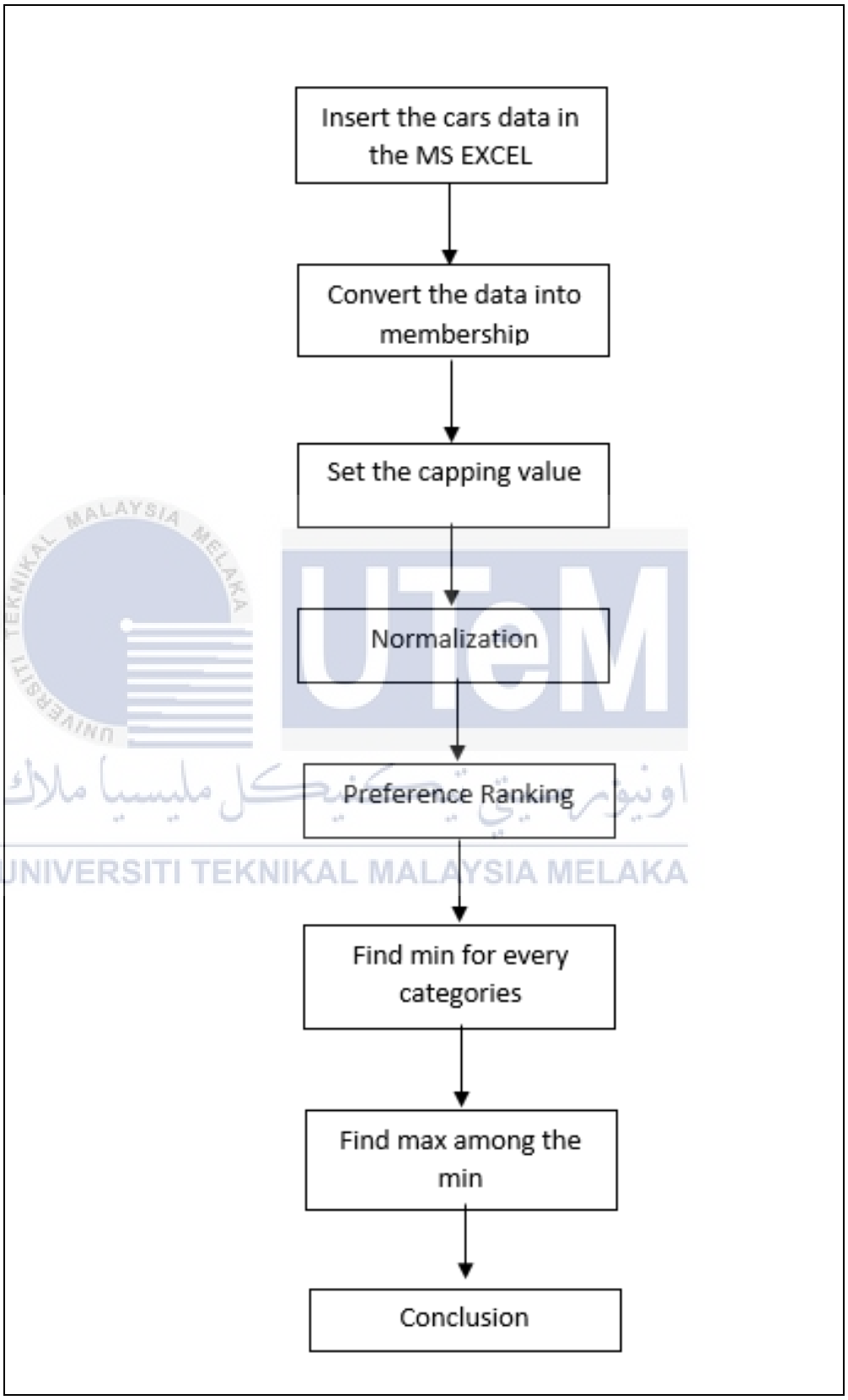
Week	Phase	Action	Deliverables
1-5	Planning	(14/10/2020) Identify title, problem statement and scope.	
		(15/10/2020) Read the literature review and read it. Write and apply the supervisor's project plan.	
		(31/10/2020) The proposal was accepted.	
		(4/11/2020) Title Define, Issue Statement, Objective and project scope.	Chapter 1: Introduction of the thesis
		(10/11/2020) Chapter 1 is carried out and submitted for review by the supervisor.	Chapter 1: Progress the report
6-7	Analysis	(24/11/2020) Studies on related jobs and events Earlier studies and results Benchmarking and Fuzzy Logic Classifying.	Chapter 2: Literature Review
10-11	Design	(21/12/2020) Research methodology on previous methodologies Oh. Analysis.	Chapter 3: Methodology and the flow of the project
12-13	Result	(28/12/2020) Get the preliminary result by using the survey	Chapter 4: Preliminary result.

1-5	Result	-Distribute the new survey to UTeM students -Build a GUI system for Benchmarking method.	Chapter 4: Result
5-10	Result and Discussion	(28/4/2021) Get the result by a new survey and analysis the summary -Change whole data to perform the survey from SUV cars to affordable cars.	Chapter 4: Result and discussion
11-12	Conclusion	(26/5/2021) Writing the conclusion and future works for the project.	Chapter 5: Conclusion and the Future works

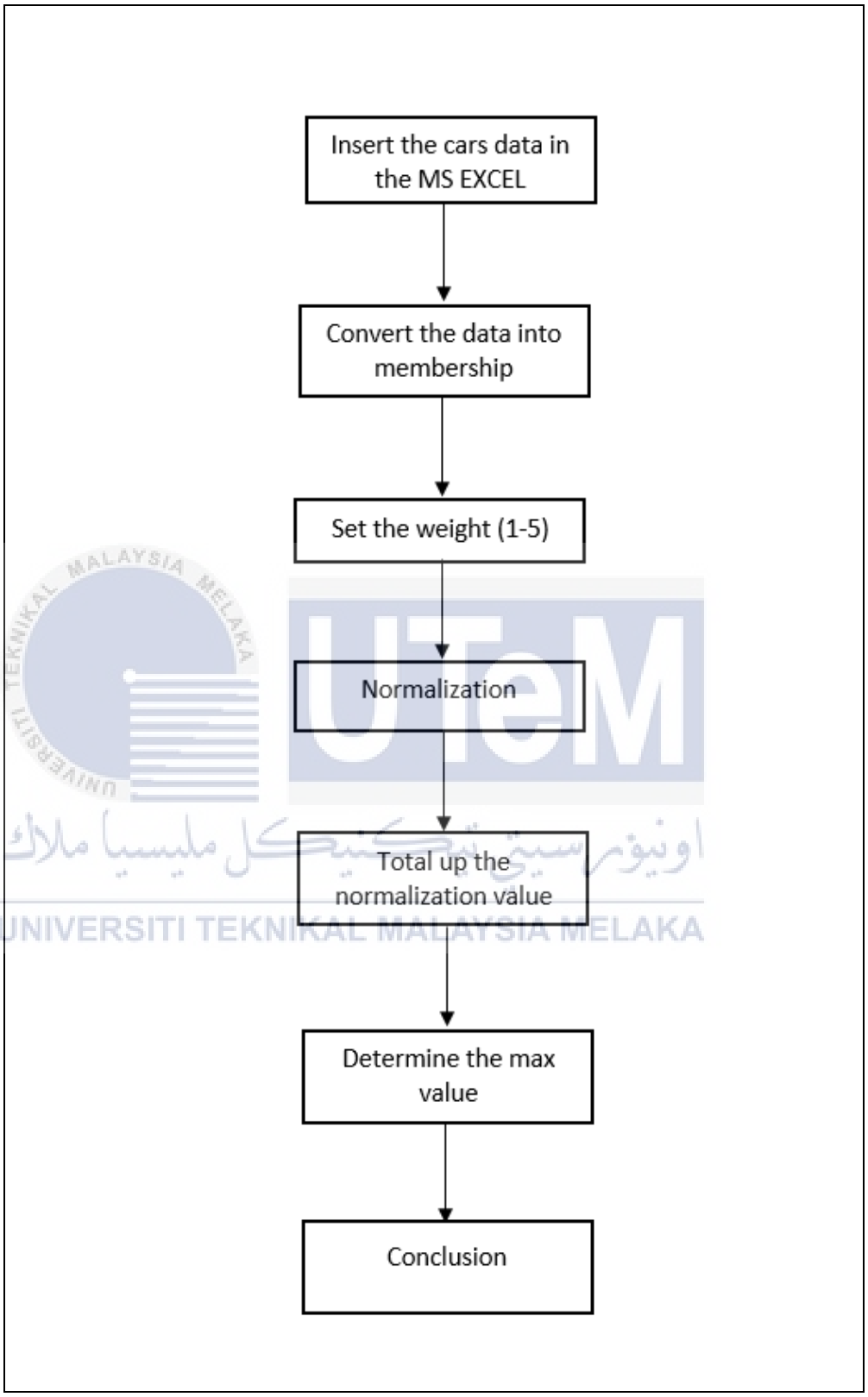
Appendix C



Appendix D



Appendix E



Appendix F

A. PERANCANGAN PROJEK

PROJECT PLANNING (GANTT CHART)

Senaraikan aktiviti-aktiviti yang berkaitan bagi projek yang dicadangkan dan nyatakan jangka masa yang diperlukan bagi setiap aktiviti.

List all the relevant activities of the proposed project and mark the period of time that is needed for each of the activities.

	SEM I																			SEM BREAK					SEM II															
Aktiviti Projek *Project Activities*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
FYP 1 Title Registration & Briefing (Online Session)											**SEMINAR PSM I**																											**SEMINAR PSM II**		
Student Seminar 1 : Project Proposal Preparation & Management																																								
Proposal Defense Submission																																								
Proposal Defense Presentation																																								
Identify problem statement, project question, project objective, and scope.																																								

Study and research the literature review.	
Analyze the formula and the sequence of the fuzzy and benchmarking	
Design and setup the sample of the methods	
Run the survey and collect the feedback and identify the preferred method.	
Thesis & Technical Report Writing Technique using Microsoft Word (Chapter 1 & 2)	
Write thesis & technical report until chapter 2	
Thesis & Technical Report Writing Technique using Microsoft Word (Chapter 3)	
Final draft submission to supervisor	
FYP 1 Seminar Week	
FYP 1 Seminar Panel & Supervisor Mark Entry	
FYP II Briefing (Online)	

Thesis & Technical Report Writing Technique using Microsoft Word (Chapter 4)	
Distribute Google form	
Thesis & Technical Report Writing Technique using Microsoft Word (Chapter 5)	
Build GUI by using MATLAB (Benchmarking method)	
Thesis & Technical Report Writing Technique using Microsoft Word (Abstract)	
INOTEK Preparation (video and Report)	
Draft Thesis submission	
INOTEK (Submission)	
FYP Seminar II week (Online)	
Final draft submission to supervisor	
Technical report submission to supervisor	
Submission of final thesis & technical report to JK PSM	

Marks entry by panels and supervisor			X

Mark “X” on the Gantt chart for the expected milestones (Hint: Completion of major activities)