UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND DEVELOPMENT OF INDOOR ORGANIC ECO-SMART GARDEN

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Manufacturing Engineering Technology (Product Design) with Honours.

by

NG SHEK YI
B071410320
941120055060

FACULTY OF ENGINEERING TECHNOLOGY
2017

© Universiti Teknikal Malaysia Melaka

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DESIGN AND DEVELOPMENT OF INDOOR ORGANIC ECO-SMART GARDEN**

SESI PENGAJIAN: **2017/18 Semester 1**

Saya **NG SHEK YI**

mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐ SULIT	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐ TERHAD	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐ TIDAK TERHAD	

Disahkan oleh:

_____ _____

Alamat Tetap:

11, Jalan Triang Indah 3,

Taman Triang Indah,

28300 Triang, Pahang.

Tarikh:_____

Cop Rasmi:

Tarikh:_____

** Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

© Universiti Teknikal Malaysia Melaka

DECLARATION

I hereby, declared this report entitled “Design and Development of Indoor Organic Eco-Smart Garden” is the results of my own research except as cited in references.

Signature : ……

Author’ s Name : NG SHEK YI

Date : ……

© Universiti Teknikal Malaysia Melaka

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering Technology (Product Design) with Honours. The member of the supervisory is as follow:

……

(Project Supervisor)

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Hari ini, lebih daripada separuh penduduk dunia menetap di bandar-bandar; pada 2050, terdapat hampir dua pertiga daripada semua orang di dunia ini akan menetap di kawasan metropolitan perbandaran. Pertanian tradisional tidak dapat menyediakan megacities itu dengan khasiat yang cukup sihat. Oleh sebab penduduk semakin bertambah dalam dunia ini, kekurangan tanah ladang, dan kebimbangan keselamatan makanan, penyelesaian terbaik adalah membawa pertanian bandar dengan diri sendiri. Pertanian bandar bermaksudnya mengamalkan penanaman, pemprosesan, dan mengedarkan makanan di dalam atau di sekitar kampung, pekan atau bandar. Kebelakangan ini, banyak syarikat telah melibat dalam kilang tumbuhan dengan teknologi yang berbeza dan reka bentuk yang berlainan taman pintar. Sedia ada taman pintar di pasaran pada masa kini yang menggabungkan dengan mereka teknologi mesti mengatasi beberapa isu asas: tidak mencukupi tambahan cahaya, kos pengeluaran mahal dan reka bentuk tidak menarik. Tujuan projek ini adalah untuk mereka bentuk taman pintar yang berciri-ciri praktikal dan padat dan membina prototaip taman pintar dengan sistem air penjimatan air dan ciri-ciri sistem lampu penjimatan kuasa. Dalam usaha untuk mengoptimumkan kos taman pintar dan mereka bentuk taman pintar dengan sistem penanaman yang berbeza, reka bentuk yang berbeza dan ciri-ciri yang berbeza daripada produk taman pintar yang sedia ada di pasaran, projek ini juga bertujuan untuk melaksanakan taman pintar dengan konsep teknologi hijau dan sangat rendah kos dibelanjakan.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

Nowadays more than half of the world's populace lives in cities; in 2050, there are nearly two thirds of all individuals on soil will live in urbanized metropolitan ranges. Conventional agriculture will not be able to supply such mega cities with sufficient healthy nourishment. Therefore, due to a continually expanding world populace, a diminish of cultivate land, and nourishment security concerns, carrying urban farming by self is the best solution. Urban farming, which implies is the practice of cultivating, processing, and distributing food in or around a village, town, or city. Lately, many companies have gotten involved in plant factories that with different technologies and different design of smart garden. Existing smart garden in market nowadays that combine with those technologies must overcome some fundamental issues: insufficient supplemental of light, expensive manufacturing cost and unattractive design. The purpose of this project is to design a smart garden that are practical and compact features and develop a smart garden prototype with water-saving watering system and power-saving lighting system features. In order to optimize the cost of smart garden and design a smart garden with different planting system, different design and different features from existing smart garden product in the market, this project also aim to implement the smart garden with go green technology concept and very low cost spent.

© Universiti Teknikal Malaysia Melaka

DEDICATION

Every challenging work needs self-efforts as well as guidance of elders, especially those who very close to our heart.

My humble effort I dedicate to my sweet and lovely

Family members

Whose affection, encouragement and prayers of day and night make me able to get such success and honour.

Project supervisor, Encik Mohd Kamal bin Musa,

Project co-supervisor, Encik Mohd Qadafie bin Ibrahim

Along with all hardworking and respected

Lecturers and friends

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

First of all, I am very thankful to my family for their lovely, support and encouragement for being with me on each and every step of my life.

I wish to express my deepest gratitude and appreciation to my supervisor, Encik Mohd Kamal bin Musa and co-supervisor Encik Mohd Qadafie bin Ibrahim for their ideas, guidance, motivation and help throughout my research. A very huge graceful was given to them, a lot of comments and ideas were given to me for helping me achieve the goal of the final year project. Furthermore, they help me a lot in checking my document report needed to be presented and suggest the best solution for me in order to solve my peradventure.

I feel very thankful for their insightful advice and suggestions. Without their support and guidance, it is impossible for me to complete my research successfully.

Special thank also to my panel who also as my examiner, Encik Mohd Nazri bin Ahmad for his guidance and helps in improvement of project in terms of ideas related to design and suggestion regarding the design theme.

Besides that, I also wish to thank to a gardener, Mr Gan for his experience in farming to vegetables, who has shared a lot of experience and knowledge about farming and gardening with me. These help me a lot, which those knowledge cannot access by reading or referring from journal.

I also thank to my BETD's course mate who have given supports to help me during this research. Last but not least, I would like to thank all the lecturers who taught me throughout my education at Universiti Teknikal Malaysia Melaka.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENT

DECLARATION i

APPROVAL ii

ABSTRAK iii

ABSTRACT iv

DEDICATION v

ACKNOWLEDGEMENT vi

TABLE OF CONTENT vii

LIST OF TABLES xii

LIST OF FIGURES xiii

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE xv

CHAPTER 1: INTRODUCTION 1

1.0 Overview 1

1.1 Background 1

1.2 Problem Statement 2

1.3 Objectives 4

1.4 Scope of Project 4

1.5 Thesis Structure 5

CHAPTER 2: LITERATURE REVIEW 7

2.0 Overview 7

2.1 Background of Smart Garden 7

2.1.1 Advantages of Smart Garden (Urban Farming) 8

© Universiti Teknikal Malaysia Melaka

2.2 Research Study on Technology Used 10
2.2.1 Study of Microcontroller 10
2.2.1.1 Arduino Uno 10
2.2.2 Study of Artificial Light 11
2.2.2.1 Light Emitting Diodes (LED) 12
2.2.3 Irrigation System 13
2.2.3.1 Surface Irrigation (Conventional Irrigation) System 13
2.2.3.2 Drip Irrigation System 15
2.2.3.3 Sprinkler Irrigation System 18
2.2.4 Planting System 20
2.2.4.1 Soil Planting System 20
2.2.4.2 Hydroponic System 21
2.2.4.3 Aquaponic System 22
2.2.4.4 Aeroponic System 24
2.2.4.5 Fertigation System 25
2.3 Plant Study 27
2.3.1 Water Spinach (Kangkong) 27
2.3.1.1 Growing Conditions 28
2.3.1.2 Crop Management 29
2.3.1.3 Harvest 29
2.3.2 Chinese Flowering Cabbage (Choy Sum) 30
2.3.2.1 Growing Conditions 30
2.3.2.2 Crop Management 31
2.3.2.3 Harvest 31
2.3.3 Spinach 32
2.3.3.1 Growing Conditions 32
2.3.3.2 Crop Management 32

© Universiti Teknikal Malaysia Melaka

2.3.3.3 Harvest 33
2.3.4 Onion 33
2.3.4.1 Growing Conditions 33
2.3.4.2 Crop Management 34
2.3.4.3 Harvest 34
2.3.5 Sweet Potato Leaves 35
2.3.5.1 Growing Conditions 35
2.3.5.2 Crop Management 35
2.3.5.3 Harvest 36

CHAPTER 3: METHODOLOGY 37
3.0 Overview 37
3.1 Project Schedule 37
3.2 Overall Project Flow Chart 39
3.3 Product Planning and Identifying Customer Needs 40
3.3.1 Product Development 40
3.3.1.1 Quality function deployment (QFD) 41
3.3.1.2 Morphological Chart 42
3.3.2 Market Research and Comparison Stage 43
3.3.2.1 Customer Need Statement 44
3.3.2.2 Benchmarking 45
3.4 Conceptual Sketch 52
3.5 Stage Explication 56
3.5.1 Final Design 56
3.5.2 Prototype 57
3.5.3 Hardware Specification 59
3.5.3.1 Timer Irrigation System 59

© Universiti Teknikal Malaysia Melaka

3.5.3.2 Light Emitting Diodes (LED) 61
3.5.3.3 Fertilizer Tank 64
3.5.3.4 Air Ventilator 65
3.5.3.5 Drainage System 65
3.6 Testing and Analysis 66

CHAPTER 4: RESULTS AND DISCUSSION 68
4.0 Overview 68
4.1 Analysis of Plant Growth Rate 68
4.1.1 Water Spinach (Kangkong) 69
4.1.2 Chinese Flowering Cabbage (Choy Sum) 70
4.1.3 Spinach 71
4.1.4 Onion 72
4.1.5 Sweet Potato Leaves 73
4.1.6 Summary of Analysis Result 74
4.2 BOM and Cost Analysis 75
4.3 Project Evaluation 76
4.3.1 Electric Consumption 76
4.3.2 Water Consumption 77
4.3.3 Reason of No Using Arduino 77

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS 79
5.0 Overview 79
5.1 Conclusion 79
5.2 Recommendations 80
5.2.1 Monitoring System 80

© Universiti Teknikal Malaysia Melaka

5.2.2 Mechanical Design 80

REFERENCES **82**

APPENDICES **86**

APPENDIX A 86

APPENDIX B 94

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

1.1 Mission Statement of Indoor Organic Eco-Smart Garden 3

2.1 Pros and Cons of Surface Irrigation System 14

2.2 Pross and Cons of Drip Irrigation System 17

2.3 Pros and Cons of Sprinkler Irrigation System 19

3.1 Project Schedule 38

3.2 Quality Function Deployment (QFD) 41

3.3 Morphological Chart 42

3.4 Customer Need Statement 44

4.1 Observation Result and PGR of Water Spinach (Kangkong) 69

4.2 Observation Result and PGR of Choy Sum 70

4.3 Observation Result and PGR of Spinach 71

4.4 Observation Result and PGR of Onion 72

4.5 Observation Result and PGR of Sweet Potato Leaves 73

4.6 Plant Growth Rate in between Fertigation Planting System and Conventional Planting System 74

4.7 BOM List and Cost 75

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

2.1	Arduino UNO	11
2.2	Photosynthetically Active Region of LED	12
2.3	Surface Irrigation (Conventional Irrigation) System	14
2.4	Drip Irrigation System	16
2.5	Sprinkler Irrigation System	18
2.6	Hydroponic System	22
2.7	Aquaponic System	24
2.8	Aeroponic System	25
2.9	Fertigation System	27
3.1	Overall Project Flow Chart	39
3.4	Taiga Tower	47
3.5	Back to the Roots Water Garden	48
3.6	Click and Grow Smart Herb Garden	49
3.7	Miracle-Gro AeroGarden	50
3.8	Lyfbox	51
3.9	Layout of Lyfbox	51
3.10	Conceptual Sketch 1	53
3.11	Conceptual Sketch 2	54
3.12	Conceptual Sketch 3	55
3.13	3D CAD Drawing (Mechanism Open View)	56
3.14	3D CAD Drawing (Mechanism Closing View)	56
3.15	Prototype Before Finishing	57

© Universiti Teknikal Malaysia Melaka

3.16	Prototype After Finishing Before Setting Up System	57
3.17	Prototype After Setting Up The Whole System	58
3.18	Isometric View of Prototype With On The System	58
3.19	Drip Irrigation Controller (Timer)	60
3.20	The Splitter Connection To The Water Sprinkler	61
3.21	Water Sprinkler Connected To The Plants	61
3.22	Schematic Diagram of The Lighting System	62
3.23	LED Light Bar	62
3.24	The Universal 2-Pin Plug	63
3.25	Universal 2-Pin Plug Adapter	63
3.26	The Internal Connection of The 3-Pin Plug	63
3.27	The Connection of Fertilizer Tank To The Timer	64
3.28	Air Ventilator Located At The Bottom of The Smart Garden	65
3.29	Well-drained System In Indoor Organic Eco-Smart Garden	65
3.30	Set Trigger Time At 9 In The Morning	66
3.31	Set Trigger Time At 6 In The Evening	66
4.1	Graph of Height of Water Spinach (Kangkong) Against Week	69
4.2	Graph of Height of Choy Sum Against Week	70
4.3	Graph of Height of Spinach Against Week	71
4.4	Graph of Height of Onion Against Week	72
4.5	Graph of Height of Sweet Potato Leaves Against Week	73
4.6	Graph of Plant Height Against Week	74

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

QFD - Quality Function Deployment

LED - Light Emitting Diodes

PGR - Plant Growth Rate

© Universiti Teknikal Malaysia Melaka

CHAPTER 1
INTRODUCTION

1.0 Overview

The overall goal for this chapter is to introduce the approaches of this project. Firstly, the general idea has been discussed and followed by the problem statement of this project has been identified. Next, the aim of the project has been explained clearly and the extent for implementation of this project has been stated. Meanwhile, this chapter has been also discussed the overall thesis structure of this project.

1.1 Background

Today more than half of the world's population lives in urban area; in 2050, there are almost two thirds of all people on earth will live in urbanized metropolitan areas. Until 2050, the number of individuals living in urban ranges is anticipated to rise to more than six billion, 90% of them in creating nations (UN, 2013). This uncommon blast and development of mega-cities around the world may demonstrate unsustainable and environmentally sad. Besides, in today's busy society, people pay more attention and spend more time to their job than to their own health. Thus, most of the people nowadays because of their busy, they solve their three meals a day casually outside. In fact, outside food can bring the convenience, but more is unhealthy. Besides, many gardeners have put chemical fertilizers on their crops to avoid damage from pest insects. Therefore, most of the vegetables we buy are filled with chemical substances. According those phenomenon, one of the solutions in used for increasing agricultural production without land planting and without chemical substances is carrying urban farming by self.

© Universiti Teknikal Malaysia Melaka

This Indoor Organic Eco-Smart Garden is a concept for growing a vegetable garden in the kitchen, without help from sun or rain. It is a fastidiously designed, self-growing cultivate that revolutionizes how new nourishment is developed. This self-growing cultivate makes a difference all plants flourish, naturally making beyond any doubt they have the right sums of water, light, oxygen, and supplements. With solid nourishments developed right on windowsill, people can enjoy a higher quality of life. This Indoor Organic Eco-Smart Garden is designed with either can attached with the wall of kitchen or just leave it alone by self.

1.2 Problem Statement

In this project, the improvement for the smart garden focus to supplemental light, cost and a smart garden with different system, design, and features. Supplemental light is important for plants to help them carry out the photosynthesis process. Hence, supplemental light would be required in arrange to get economically viable yields. Other than that, the supplemental light could be provide light in 24 hours. This means that the supplemental light must selected suitable used for 24 hours continuously and ensure sufficient light supply for plants. For implementation and innovation to this existing product, one of the main requirements is reducing its cost. There are many smart gardens sold in the market, where they are designed with different planting system, different design, different features and so on. However, the cost of them mostly are very expensive. According to Bruce Bugbee, a crop physiologist at Utah State University, believes that the power demands of urban farming will be too costly and uncompetitive with traditional cultivating using only free natural light. The environment author George Monbiot calculated that the fetched of giving sufficient supplementary light to grow the grain for a single loaf would be almost $15. An article in the Economist argued that "even though crops growing in a glass skyscraper will get some natural sunlight during the day, it won't be enough," and "the cost of powering artificial lights will make indoor farming prohibitively expensive".

© Universiti Teknikal Malaysia Melaka

Once the project has been endorsed, but before substantial resources are applied, a pre-project planning activity takes place. At this point, the earlier opportunity statement has been rewritten as a product vision statement. In order objective defined by a product vision statement may be very general. To provide a clear guidance, a more detailed definition of the target market and of the assumptions under which the development team will operate have been formula. And following is the mission statement for this project outcome product, Indoor Organic Eco-Smart Garden:

Table 1.1: Mission Statement of Indoor Organic Eco-Smart Garden

Mission Statement: Indoor Organic Eco-Smart Garden	
Product Description	• Can irrigating the plants automatically. • Can provide light to the plants when switch on the system. • Can fertilize the crops automatically.
Key Business Goals	• Be widely used in daily life. • Serve as practical and compact size to fit and save the housing area space for urban citizens. • Serve as time saving, chemical free and transportation free product. • Serve as platform for all future horticulture field products and solutions.
Primary Market	• Capture 50% of electronic product sales in primary market • Environmentally friendly • Office departments, urban residential (minimum 500sqft, without balcony amenities)
Secondary Markets	• Urban citizens can be used it especially those having busy lifestyle. • Electronic hardware and device market.
Assumptions and Constraints	• New product platform • Electronic imaging technology • Input devices manufactured in Malaysia

© Universiti Teknikal Malaysia Melaka

	• Output devices manufactured in Malaysia • Image processing engine manufactured in Malaysia. • Mechanism of indoor smart garden system should be tested in Malaysia.
Stakeholders	• Purchasers and users • Manufacturing operations • Service operations • Distributors and resellers

1.3 Objectives

The main objectives of this project are aimed to the problem statement stated:

1. To design a smart garden that are practical and compact features.
2. To develop a smart garden prototype with water-saving watering system and power-saving lighting system features.
3. To implement the smart garden with go green technology concept and very low cost spent.

1.4 Scope of Project

This project focuses on the innovation of existing concept, Indoor Organic Smart Garden is suitable for all house use especially for urban citizens. To innovate from existing product, the main challenge is optimising its manufacture cost as compared with the existing product in market. The technology used for this product is fertigation growing plant method. Other than that, this project also will focus in power-saving lighting system and water-saving watering system for its innovation. For this project, automatically lighting system will used, it will automatically light up to the desired wavelength of light on time when the user on the power supply, and plants needed light on that time to carry out photosynthesis. This will increase the

© Universiti Teknikal Malaysia Melaka

productivity of plants growing (reduce the time to growing, shorter the time to harvest), since plants can carry out photosynthesis process all the time. Besides, smart watering system is automated, same functional like existing product. The enzymes produced is made by the residual of fruits peel or vegetables, so that it will not the unpleasant smell.

This project will cover the design process and development of the indoor smart garden and study of which species of plants that are suitable and recommended for growing indoor and used it by this Indoor Organic Eco-Smart Garden. This project is followed by the detail drawing of indoor smart garden by using Solidworks, process of prototyping the product and the planning to realize it with manufacturing process. A prototype has been planned and discussed, and a cost analysis developed on its basis. Through the analysis of the market potential, different future markets were identified. Furthermore, study of suitable ratio for fertilizer liquid mixer and monitor fertilizer liquid flow also will be covered. Lastly, conclusion and recommendation according to this product are made for further development.

1.5 Thesis Structure

This section is to explain about the overview of the thesis going to be done. In chapter 1, there are background, overview of the project and scope of project which is generally talk about the construction of smart garden. There are also have some problem statement which are going to be solved according to the objectives stated.

Chapter 2 is the literature review of the whole project. In this chapter, there are a lot of student paper, public source and internet source were read and come out with own idea in creating the construction of smart garden.

After studying all the paper and source from the internet, methodology was started which is placed in chapter 3. In chapter 3, there is the flowchart of overall progress and the flowchart of the development of prototype of smart garden. This chapter also has mentioned the steps to construct and create the smart garden design by using design and development method. In this chapter, Quality Function

© Universiti Teknikal Malaysia Melaka

Deployment (QFD), Morphological Chart, customer need statement and benchmarking to related product have been clearly discussed and stated. The implemented processes, hardware or components to build up in this project will also be specified explained in this chapter.

Chapter 4 is the results and discussion of this project. In this chapter, all the analysis result has been discussed in this chapter. Those analysis results include result of plant growth rate for each different kind of plants, Bills of Material (BOM) and cost analysis result of the smart garden. All the analysis result of smart garden has been recorded and stated in a table and figure, thus it is more easily to understand for other people or student. Generally, chapter 4 is the way how a student analysed the data obtain from the project, so it is importance for the student or people who are going to read.

Lastly, in chapter 5, conclusions and recommendations where be cover in this chapter, all the sustainability, commercialization and future work will be stated in it and the achievement of the objective also will be mentioned to prove the progress is successful or not.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2
LITERATURE REVIEW

2.0 Overview

This chapter will discuss on the background of the smart garden, technology used for growing crops in terms of lighting system, irrigation system and planting system, study of each different species of plants in term of fast growing, indoor growing suitability and popularity for Malaysian and competitors. As for the design method, all required information obtained from journals that have been done by other researches previously.

2.1 Background of Smart Garden

The worldwide projections appear that up to 2040 agrarian arrive can as it were be raised by only another 2% (Banerjee & Adenaeuer, 2014). Due to population escalating up day by day meanwhile diminishing farm land in the world, producing enough food supply has become one of the serious global issues. According to Emmott, by 2050, the world population will be increase to at least nine billion, at the same time, food demand will speed up at a far faster rate than population growth (Emmott, 2013). One of the issues that people concerned about is nowadays, water also is a scarce resource. From this, this require to minimize the negative ecological impacts of agriculture, especially with respect to greenhouse gas emissions, soil degradation, and the protection of already dwindling water supplies and biodiversity arises. Subsequently, we must attempt to discover some agricultural technologies that have a neutral or positive impact on our environment. Due to climate change, producing crops steadily is a troublesome thing to do. There are many safety concerns for food because

© Universiti Teknikal Malaysia Melaka