



**A RELATIONSHIP WITH NATURE: SYSTEMS AND METHODS
FOR BETTER INTEGRATING GREENERY INTO OUR LIVES**

**BY
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เข้ากับชีวิตของเรา



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กิตติกรรมประกาศ

วิทยานิพนธ์ฉบับนี้สำเร็จได้เป็นอย่างดีเนื่องมาจากได้รับความอนุเคราะห์จาก อาจารย์ David Shafer อาจารย์ ชีรนพ หวังศิลาปะคุณ และ อาจารย์ Sridhar Ryalie ที่ช่วยเหลือให้คำแนะนำ และให้ความเอาใจใส่ช่วยเหลือและคอยให้คำปรึกษาแนะนำเป็นอย่างดีมาโดยตลอด ขอบขอบคุณ และครอบครัวที่เข้าใจและให้กำลังใจตลอดการเรียน

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Abstract

Despite the fact that centers of urban continue to grow, and the populations increase more and more, most people surprisingly spend more of their time indoors, isolated from the natural environment. Recently, this trend has remarkably intensified by the prolonged COVID-19 outbreak and excessive air pollution. This unusual moment has resulted in urban dwellers began to seriously seek to improve their indoor environments. For instance, they have been purchasing and attempting to care for potted plants, which often ended with varying levels of success since certain plants have certain needs, understanding and accommodating these needs can quickly become confusing and lead to frustration.

For this reason, this study aims to simplify the methodologies to cultivate nature indoors and design a system where both plants and humans can thrive in today's context. The authors bring their own experiences, problems encountered, and knowledge gathered from a wide variety of online blogs, forums, social media groups, instructional videos from both amateur and professional YouTubers, printed articles and books, as well as direct discussions with fellow enthusiasts and experienced professionals to design the plant care system that consisted of 3 parts; 1) Plant care cards that simplify complex knowledge for easier understanding, 2) Plant pots for caring four groups of plants; plants that need moderate moisture, plants that need more moisture, plants that need less moisture, and plants that can be grown in a semi-hydro, and 3) An application that provides plant care information and reminders for watering, fertilizing, changing soil, and assessing plant health. The result is that the urban dwellers can grow and care for indoor plants in an easier way. The plant pots have the potential to help the plants thrive in urban residences. The system can support the determination and desire of the urban dwellers by connecting them with nature and enjoying their daily life by integrating greenery into their life.

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บทคัดย่อ

ในขณะที่ใจกลางเมืองยังคงเติบโตและมีประชากรหนาแน่นขึ้นเรื่อย ๆ ประชากรใช้เวลาส่วนใหญ่อยู่ในบ้านมากขึ้น โดยแยกออกจากสภาพแวดล้อมทางธรรมชาติ และเมื่อเร็ว ๆ นี้ แนวโน้มดังกล่าวทวีความรุนแรงขึ้นอย่างมากเนื่องจากการระบาดของ COVID-19 ที่ยืดเยื้อและมลพิษทางอากาศที่มากขึ้นไป ในช่วงเวลาที่ผุดปกตินี้ได้สะท้อนให้เห็นถึงกิจกรรมที่ชาวเมืองเริ่มพยายามที่จะปรับปรุงสภาพแวดล้อมภายในอาคารอย่างจริงจัง ยกตัวอย่างเช่นการซื้อและการพยายามดูแลไม้กระถางซึ่งมักมีความสำเร็จที่แตกต่างกันออกไปเนื่องจากพืชแต่ละชนิดมีระดับความต้องการในการดูแลที่ต่างกัน ซึ่งอาจทำให้เกิดความสับสนและนำไปสู่ความยุ่งยาก

วัตถุประสงค์ของการศึกษานี้เพื่อลดความซับซ้อนของวิธีการปลูกพืชภายในที่พักอาศัยและออกแบบระบบที่ช่วยให้พืชสามารถเจริญเติบโตอยู่ร่วมกับมนุษย์ได้ในบริบทของปัจจุบัน ผู้เขียนได้นำประสบการณ์ของตนเอง ปัญหาที่พบ และการรวบรวมความรู้จากบล็อกกลุ่มโซเชียลมีเดีย วิดีโอการเรียนการสอนจากยูทูบ ทั้งมีสมาธิและมีความสุขบทความและหนังสือ ตลอดจนการสนทนาโดยตรงกับผู้ชื่นชอบและผู้เชี่ยวชาญที่มีประสบการณ์เกี่ยวกับการปลูกพืช มาออกแบบระบบซึ่งประกอบด้วย 3 ส่วนสำคัญดังนี้ 1) การคัดข้อมูลดูแลพืช ที่นำองค์ความรู้ที่ซับซ้อนนำมาออกแบบให้สามารถสื่อสารและทำความเข้าใจให้ง่ายขึ้นในการ 2) กระถางต้นไม้สำหรับการดูแลพืชกลุ่ม กลุ่มพืชที่ต้องการความชื้นปานกลาง ความชื้นมากความชื้นน้อย และสำหรับพืชในระบบกึ่งน้ำ 3 แอปพลิเคชัน ที่มีข้อมูลการดูแลพืชและแนวคิดในการตั้งค่าการแจ้งเตือนเวลาสำหรับการรดน้ำการใส่ปุ๋ยการเปลี่ยนดินและการประเมินสุขภาพของพืช ผลที่ได้คือผู้ปลูกสามารถปลูกและดูแลพืชในร่วมด้วยวิธีการที่ง่ายขึ้น กระถางต้นไม้มีศักยภาพที่จะช่วยให้พืชเจริญเติบโตได้ในที่พักอาศัย ระบบสามารถสนับสนุนความมุ่งมั่นและความปรารถนาของผู้ปลูกให้ได้รับความสุขในชีวิตประจำวันโดยสามารถผสมผสานความเขียวขจีเข้ากับชีวิตของเราได้

(วิทยานิพนธ์มีจำนวนทั้งสิ้น 72 หน้า)

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Chapter 1

Introduction

1.1 Background and Significance of the Problem

More and more people live in urban areas than rural areas, with 55% of the world's population living in urban areas in 2018 and by 2050 it is estimated that 68% of the world's population will be in cities (World Health Organization, 2014). Most people spend 90% of their time indoors and almost 70% are at home (Klepeis et al., n.d.), (Figure 1.1). During the recent quarantine period of the COVID-19 outbreak, people were stressed and anxious to constantly check news about the situation and were forced to spend most of their time at home. The surrounding environment also affects people's well-being and their daily life (Brown, Barton, & Gladwell, 2013). Maintaining Our Lives in Good Health is the most obvious example of a development focusing on biophilic design that seeks to blend nature into indoor spaces. Also, the biological and naturalist hypothesis of Edward O. Wilson pointed out that "Humans have an innate tendency to seek connections with nature and other forms of life" to reduce anxiety and stress, improving our overall health (Pieranunzi, 2020).

Since ancient times, humans have had the prime desire to surround themselves with nature and bring plants into their homes. Even though humanity has now become urbanized, the impulse has never disappeared. Plants became a symbol of status in the early model era for the elite to show off their wealth and use the collection of their exotic plants in greenhouses as a projection of their worth in much the same way that they would art and architecture. With the advent of the industrial revolution, mass production, and advanced shipping, the masses could also afford to have plants at home, and they began to fill them with exotic plants bought from far-off lands.

In the present times, we see new trends on social media. Various websites suggest growing plants and provide very detailed instructions on choosing appropriate plants and suggestions on how to grow and care for the plants. We can find many pictures of the plants decorated inside homes in countless Instagram and Pinterest feeds, which have become tools for connecting with others interested in indoor plants and can reach millions of people sharing their stories and leading to new relationships (Gareth, 2020).

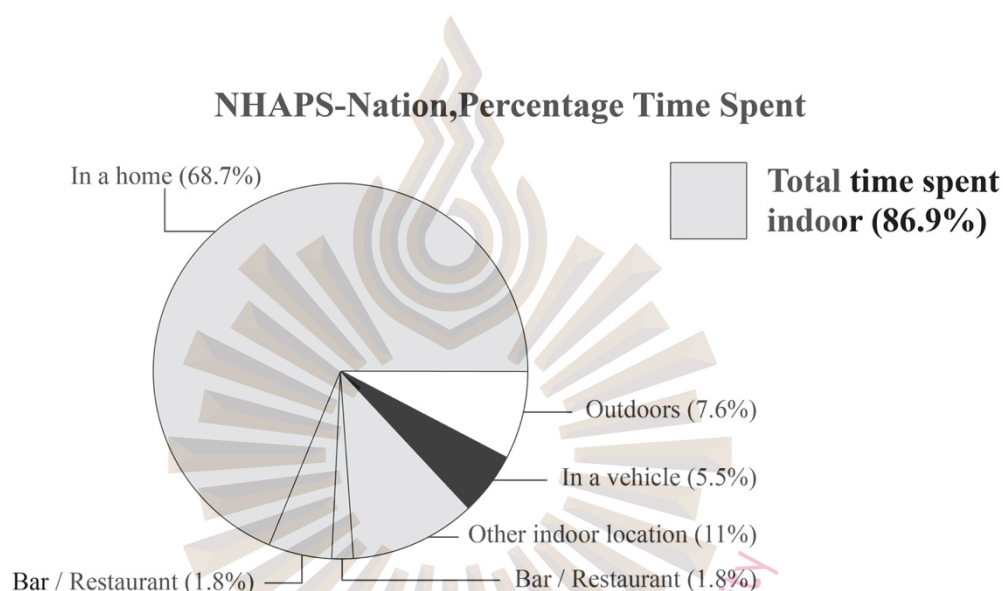


Figure 1.1 Pie showing the percentage of the NHAPS respondents spent in six different locations on the diary day

Source: Klepeis et al., 2001

Other information that encourages more and more people to pay attention to plant and tree planting activities comes from a project led by the National Aeronautics and Space Administration (NASA) in collaboration with the Associated Landscape Contractor of America (ALCA) to research ways to clean the air in confines space like the space station and manage the carbon dioxide and oxygen released through photosynthesis. Some indoor plants can naturally remove volatile organic pollutants (Cruz et al., 2014)

Connecting with nature isn't always easy as it depends on where one lives. For example, if someone lives in a city not close to a park, going outside might not be much

different from being indoors (Smith, 2020). Although planting plants is the easiest way to approach nature, it is not easy to cultivate indoor plants if they lack knowledge and understanding of growing individual plants' different care needs. Because most of the plants we grow indoors are outdoor plants from warm countries that originate in rain forests, deserts, or mountain areas. They have different likes and dislikes in terms of light, warmth, humidity, and water. As a result of growing a plant in unsuitable conditions, the plant is stressed when adjusting to the new environment and eventually dies (Raworth & Bradley, 1988). The problem with growing indoor plants for urban gardeners is the lack of understanding about the plants. Proper planting and care, there is a wealth of information about plants and plant care available on the Internet and horticultural books, but they are not specific to indoor plant care.

As the details and problems above, the authors have had the idea to design systems and kits that will help us connect with nature and integrate it into our lives. Systematic planting would relieve plant care concerns with recommendations on the appropriate indoor plants being grown. The authors have studied various types of popular plants for indoor cultivation, classified the needs and relevant factors for each plant, and then used all this information to establish a primary care system to integrate greenery into our lives, with the hope to make people closer to nature.

1.2 Research Objectives

To design a system for planting indoor plants that takes into account the problems aroused among the indoor plants

1.3 Research Questions/ Assumptions

The planting plants indoors. It is one of the activities that is getting more and more attention today, due to the situation of Covid-19, including air pollution makes people stay in the shelter away from nature. That has led many people, including the author develops a better living environment in their homes by planting various potted plants to get closer to nature, Create a green corner or area and find relaxing activities

within the property. But growing indoor plants is not easy. Knowledge is complex and sometimes confusing due to the abundance of planting data and sometimes not specific to the care of indoor plants. In addition, each plant has different needs for care factors. It isn't easy to understand for beginners. The results of growing indoor plants have different levels of success. Common problems arise from many misunderstandings. For example, they are choosing the type of plant that is unsuitable for indoor growing. They don't know how to care for each plant properly. When the plant has an abnormality, they not known the cause of the problems. Therefore, the author is interested in using the above issues to design systems, methods, and devices. To help plants grow and humans can coexist with nature within the shelter in today's context.

This study aims to care for potted plants grown indoors or in residential areas where space is limited and may have environmental conditions or factors that are not suitable for plant growth. Reduce the problem of improper care that is the cause of the death of grown indoors. The plants are divided into three types: Tropical evergreen forest, Tropical rain forest, Desert (Cacti & Succulents), divided according to the care characteristics. The criteria for essential plant factors such as planting material, the density of light, humidity, and water were used as a guideline for grouping. To make it easier to understand and use as information for developing systems and equipment to help care for indoor plants in particular. The system can suit the needs of each plant properly and is easy for the grower to understand and use. Novice growers have been successful in caring for indoor potted plants.

1.4 Research Framework

1.4.1 Study popular indoor plants to identify needs and care factors to design a suitable care system for the selected plants

1.4.2 Experiment by planting the selected plants according to the instructions and gather the care methods for plants from online sellers and plant nurseries

1.4.3 Design a system for indoor planting.

1.4.4 Create a prototype of the pot kit made from transparency acrylic sheet and online handouts by trying out the planting process

1.5 Definition of Terms

Indoor plants are plants that thrive even indoors with little sunlight or have poor lighting conditions, and easy to care for do not need frequent watering. Some are also effective in purifying the air in the room as well.

Tropical forests Tropical rain forests grow around the equator in South America, Africa, and Southeast Asia. They have the highest species diversity per area in the world, containing millions of different species. Even though they cover only a small part of the earth, they house at least one-half of all species. The temperature is stable year-round, around 27°C. It rains a lot in these forests. Most tropical forests receive at least 200 cm (80 inches) of rain in a year. Tropical forests generally have a rainy and dry season.

Potting soil also known as potting mix, comprises various ingredients that provide a healthy environment for potted plants to grow. These mixes are designed to keep the soil from becoming too compacted, which can suffocate roots and impede the flow of water and nutrients. A high-quality potting mix will be lighter weight and fluffy, with the ability to hold moisture. There are many different types of all-purpose blends, as well as more specialized mixes

Chapter 2

Literature Review

This chapter focuses on the study of fundamental factors for plant growth. Techniques for proper care for indoor plants. Learn how to solve the problem that causes the death of indoor plants quickly. To lead to the design of the appropriate care system

2.1 A study the types of plants that can be grown indoors

Choosing the right type or cultivar for the environment is of the utmost importance because a common problem when growing plants indoors is that the plants will not last for long due to different indoor environments from the original natural habitat of that plant.

Growers must understand the source of the plant because each plant has a different origin. Therefore, factors suitable for growing are various, such as the amount of light, type of planting material, water content, humidity, and temperature, etc.

Environmental change of plants from nature to raise them in a new environment such as in the building, condominium, etc. So suddenly, different from the original environment stresses the plant. Plants need time to adapt to the new environment, but if plants are not adaptable. Plants will show signs of problems quickly with improper care and if novice growers do not know how to solve issues promptly. The plant eventually dies (Raworth & Bradley, 1988).

Therefore, knowing the types of plants for choosing the right plants. A quickly adaptable plant or can grow in a variety of environments. Consequently, it is an excellent solution to start growing plants inside the accommodation. By categorizing plants to

make it easier to consider choosing and planting and taking care of them properly as follows:

2.1.1 Flowering and foliage plants

Flowering plants are mainly grown for flowers. They tend to require more light than foliage plants. Some will bloom all year round. Will bloom only in certain seasons during other flowers, including African violets, Bromeliad, Begonias, Delhi, Orchids, *Episcia cupreata*, etc.

Foliage plants are grown primarily for their leaves. Their native environment is usually the tropical rainforests of Central and South America. They grow outdoors under tall trees because they require low light, and They are proper in rooms with little light or dark corners. Their colors may be any shade of green. Or even pink, orange, yellow, red, and purple (Rollins, 1989). The leaves may be plain, striped, flecked, or spotted. Foliage plants include Ficus Tree, Palm, *Dracaena*, *Philodendron*, *Monstera*, *Cordyline fruticosa*, *Clusia major* L., Rubber Plant, *Aglaonema*, and Dumb cane, *Epipremnum Aureum*, *Calathea*, *Syngonium* etc (Puangkim, 2011).

Notice of this type of plant includes thick, succulent leaves, strong stems, some with rubber, fast-growing, and easy to care for.

2.1.2 Tuber crops

The shape of the head and flower is uniquely attractive. The tuber was used to decorate the interior of the building. Choosing to plant consider the size of the tuber suitable for the shape of the planting container—popularly grown to see stem tubers form. The method of planting is to bury the stem and root shallowly in the planting material to appreciate the beauty of the stem tubers' form, texture, leaf, and flower color. The beauty of this plant is expressed only in its season, and beauty ends when the season has passed. The flowering season for tubers is during the rainy season and leaves the leaves and flowers in the summer. The popular tuber crops include *Amaryllis*, *Haemanthus multiflorus*, *Stephania erecta* Craib, *Stephania nova*, etc.

These plants are drought tolerant due to their stems full of water and nutrients, easy to care for, and require only infrequent watering. Alternatively, it can be watered every day, but the planting material used must be well-drained. Contains complete nutrients. These plants can be grown in the shade but they only give the small leaves and the branches stretching to find the light. Therefore, if growers want the tubers to produce a lot of leaves and larger ones, they should be planted in full sunlight throughout the day.

2.1.3 Cactus & Succulents

It is a plant that comes from dry areas. Therefore, the care characteristics of these types of plants differ from flowering and foliage plants. Cacti and succulents prefer drought. They need soil that well-drainage, and do not require frequent watering, need a large amount of light to create beautiful colors. It can be at a high temperature. Therefore, it is essential to provide a factor of the right amount of light and particularly well-draining plant material when choosing this type of planting.

2.2 Factors affecting plant growth

The primary factors essential to plant growth are affected by light, temperature, humidity, water, nutrients, and planting material (Pennisi, 2020) to keep the plants growing healthy and thriving as follows; (Puangkim, 2011)

2.2.1 Light

Different plants require different light intensity. Light is needed for plants to produce food and survive. Some plants thrive in bright sunlight all day long. Some require low light. However, some plants survive and thrive in both light conditions.

Light is measured in units call footcandles. One footcandles (ft-c) is the amount of light cast by a candle on a white surface in a completely dark room. Outdoors, the

light levels on a bright day range from 10,000 ft-c in an open sunny area to 250 ft-c or less in the shade of a large tree.

The light readings, can be divided into four areas, which have the following light level for 8 hours per day:

- 1) Low-light areas: 25 ft-c to 75 ft-c [center of a room, a hallway, or an inside wall, Northern]
- 2) Medium-light areas: 75 ft-c to 200 ft-c [South & East and West windows that do not receive direct sun.]
- 3) High-light areas: Over 200 ft-c, but not direct sun [South-East, West window]
- 4) Sunny light areas: at least 4 hours of direct sunlight

Therefore, the light needs of each plant are important to consider as a primary consideration when growing plants indoors. Indoors there is often inadequate lighting for growth. Once we understand each plant's light characteristics and light requirements, It will allow us to locate the light for the plants in the room. Plants get the right amount of light. Alternatively, where the room does not have a natural light source through the window, the grower may provide the plants with additional artificial lighting.

2.2.2 Temperature

Each plant grows well in different temperature ranges. Because the popular plants are native plants that come from different natural environments. However, many plants are adaptable and thrive in all temperature conditions. The ornamental plants that we see commonly in the market. It is an indicator that they can thrive in this environment, soil, or temperature because native plants and imported plants have long been developed or adapted to the local environment.

The best temperature range for indoor plants is

- 1) Cool: 10°C night, 18.3°C day temperatures
- 2) Average: 18.3°C night, 23.8°C day temperatures

3) Warm: 21.1°C night, 29.4°C day temperatures

2.2.3 Humidity

Humidity for plants is divided into two types: soil moisture and air humidity.

1) Soil moisture or planting materials moisture are directly related to water absorption and nutrients by plants. Making the planting material soggy long-term flooding of roots will reduce the amount of air in the soil. When the roots lack air, the plant shows signs of withering, roots rot, and eventually, die. Each plant likes a different amount of moisture. Some cultivars may be tolerant of high humidity soils. Therefore, knowledge in this part will help understand the amount of water suitable for each plant. It is also the basis for planting material for each plant that requires a different humidity. For example, Plants requiring high humidity should have a mixture of planting materials that can hold water or retain moisture well, such as Coco chips, husks, coco coir, bark, nut shells, Etc. In case of plants that require low humidity. The grower should mix the planting material that makes the soil loose and airy by adding perlite, pumice, sand, gravel, charcoal or clay balls, Etc.

2) Air humidity directly affects plant leaf transpiration. When the humidity of the air is high, dehydration is reduced. However, if the air humidity is low or relatively dry, the dehydration is more. If the root uptake is insufficient to replace each other, the plant will sign leaf wilt and dry edge, and the plant may dormancy or die if symptoms persist for a long time. Different plants have different rates of transpiration. The type of plant has large leaves, thick leaves, soft leaves, succulents, or hairy leaves. They are often those with a high rate of dehydration. Dehydration will be even more intense when the humidity in the air is reduced and the sweltering heat—for example, Calathea, Homalomena, Colocasia, and Caladium. Therefore, humidity is another factor in determining the selection of plants to grow indoors. Alternatively,

For interior plants, relative humidity below 20 percent is considered low, 40 to

50 percent is medium, and above 50 percent is high. Most indoor plants come from the tropical where high relative humidity is common. Therefore, take the following step to help your plants adjust to the low relative humidity in your room. Growers can find ways to add proper humidity to plants follows;

- 1) Create microenvironment with higher relative humidity
- 2) Use shallow container fill with water and lava rock or gravel which will provide evaporation from large surface area and increase relative humidity.
- 3) Use humidifier
- 4) Use mist bottles to spray water around the plant.

2.2.4 Soil/Growing medium

The growing media provides anchorage, water, and minerals. When repotting plants, make sure the new mixture is well-drained and aerated, holds water and nutrients well, and within the proper pH range (5.0-6.5). A good potting mix provides ample amounts of oxygen to the root system. Most indoor plants are planted in pots with limited space. There need proper moisture in the soil and nutrients, so the preparation or mixing of planting material is also essential. There are many different types of planting media. They have different properties as follows; (Courtney, Nd).

2.2.4.1 Soil Builders

(1) Sphagnum : is natural plant material offers structure, aeration, and water holding capacity. It's lightweight and basically sterile and slightly acidic. Sphagnum decays slowly and tends to compact over time.

There are two forms of Sphagnum commonly used for houseplants:

(1.1) Dried Sphagnum Moss: It is freshly harvested and dried Sphagnum. They are often sold in green, brown, or gray long fibers.

(1.2) Peat Moss: Natural Rotting Sphagnum Moss caused by decomposition for a long time, precipitated into layers. The moss died, and new living plants grew on the tops.

(2) Coconut coir: This natural material has gained popularity in recent years. Made from coconut husk fibers, They are more hygroscopic than peat moss. Coconut has a neutral pH, so it is less acidic than peat moss. It does not compact over time. Coir is lightweight and easy to use. It is also high in potassium, which may interfere with calcium absorption in some plants. Therefore, once the properties of the planting medium are known, the growers will be able to mix the potting mix in different ratios. To be suitable for plants that have different needs for each species.

2.2.4.2 Aeration and drainage materials

Sphagnum and coco coir provide absorbency and structure, but plants also need air and drainage. These common amendments provide it:

(1) Perlite

This popular material is volcanic glass that's been heated to the point it bursts into fragments. It's naturally occurring, non-toxic, and reusable, though it does slowly decompose. It's sterile and has a neutral pH. The most important property of perlite is how well it aerates the mix. Absorb some water and fertilizer to keep them available to the roots for longer periods. It helps to keep the temperature from being too high and prevents soil from clumping.

(2) Pumice

pumice is a natural soil conditioner similar to perlite. The flesh is porous, hollow, lightweight, water-absorbing and well ventilated. Helps to absorb the moisture of the surrounding moist soil. strengthens the roots of plants reduces water loss and increase growth Suitable for mixing into potting soil.

(3) Vermiculite

Minerals in the mica group. There are crystals stacked in layers and water between the layers. Through the fire to break up and swell up like small worms. Vermiculite contains nutrients, potassium, magnesium and calcium. Can hold

water and transfer air. Suitable for mixing into potting soil. The service life is about 2 years (because there will be a collapse).

(4) Poppers

A material made from clay similar to brick making. Produced into round balls, 1 - 2 cm in diameter, porous, so they can retain moisture. and can drain well. Suitable for mixing into potting soil. or sprinkle the soil.

(5) Japanese clay (AKADAMA)

Soils from mountain soils are porous and retain water and air in the soil grains. including complete nutrients Suitable for mixing into potting soil. or sprinkle the soil Used to grow bonsai in the bonsai growing industry widely. There are many sizes.

(6) Sand

materials such as natural granular matter Formed from rocks that have been broken down into fine grains. Increases the transparency and moisture of the soil. Suitable for mixing into potting soil.

(7) Wood Chips

Fresh wood chips provide aeration and absorption capacity, but also decompose rapidly and use up soil nitrogen in the process. Pine is more desirable than hardwoods as it takes away less nitrogen.

(8) Pine bark

Bark provides aeration, but it's not absorbent: it contains wax that repels water to protect the tree. Bark doesn't break down as quickly as wood, but it does use nitrogen as it decays and adds acidity to the soil.

(9) Charcoal

Some gardeners put charcoal in the bottom of pots or mix it in the soil. This can reduce odors and provide limited aeration but don't take claims of toxin absorption and pest-control too seriously.

Therefore, when the properties of planting material are known. The Grower will be able to mix the potting mix in different formular. To suit plants that have different needs for each species.

2.2.5 Water Quantity

Learning to water is one of the most important skills in plant care. Applying too much water can suffocate plant roots, and too little water causes growth to become erratic and stunted. Watering frequency will depend on the conditions under which the plants are growing. When dealing with how much water to apply, consider the following:

- 1) Plants type: Not all plants are similar in their water requirements. This information, along with the light preference, is usually included on the plant's label. For example, a croton, which prefers high light, will likely need more frequent watering than a succulent plant such as Opuntia cactus. Both have similar light needs but different water requirements.
- 2) Plant size: Larger plants need more water compared to smaller plants.
- 3) Container volume: If the growing container is too small, watering may be required more frequently.
- 4) Soil moisture: The amount of water already present in the growing medium will also affect watering frequency.
- 5) Light intensity: Plants under high light transpire more water compared with plants under low light.

Improper watering causes many problems. Containers with saucers may cause an excessive build-up of soluble salts (from the applied fertilizer). High levels of soluble salts can cause damage to plant roots and a decline in growth. Discard any water that had drained in the saucer after irrigation, and apply large quantities of water to the soil to leach the accumulated soluble salts in deciding when should water, feel the soil by pushing a finger an inch or so below the surface. If the soil is still moist, no further water is needed. Water devices or water meters are also available to simplify watering.

2.2.6 Nutrition

Plants require 16 different nutrients, in addition to carbon dioxide and water, to manufacture food for growth. Three major plant nutrients from air and water are carbon, hydrogen, and oxygen, with the other 13 coming from pot planting materials and fertilizer.

The three nutrients needed in the largest amounts are nitrogen (N) for healthy foliage, Phosphorus (P) for flower development, and potassium (K) for root growth. These elements are commonly provided by adding fertilizer to the potting mix. The potting mix contains very little fertilizer. Fertilizers should be applied to plants regularly when they are actively growing. Plants like African violet may be fertilized lightly every two weeks. Most foliage plants only need 3 to 4 times a year of fertilizer, starting in March and ending in September.

Fertilizers have numbers on their labels that indicate the amount or percentage of nitrogen (N), phosphorus (P), and potassium (K) found in fertilizers. Many fertilizers are made from minerals that are mined from the soil and processed. Other fertilizers are organic fertilizers and may come from the by-products of plants and animals. Minerals and organic fertilizers are equally productive plants. When added to the potting mix, plants will use organic fertilizers faster than mineral fertilizers. Fertilizers in powder, granules, or liquid form are the easiest to use. The most economical is powder. Which can be mixed with water when necessary. It is very important to read and follow the label instructions carefully when applying fertilizer. Fertilize only when the plants are actively growing. Usually, in spring and summer, Do not fertilize unhealthy or underdeveloped plants. Excess fertilizer will only cause more root damage. Tall, succulent plants with brown bordered leaves are one way the plant has been shown to be overfertilized. If a houseplant pot has white stains around the rim, there is too much mineral buildup from the fertilizer.

2.3 Selecting Containers

Growers can enhance the decorative value of the plants. Consider the following;

- 1) Suitability for the plant's needs
- 2) Suitability for the needs of the individual and the environment
- 3) Cost and availability
- 4) Strength and durability
- 5) Drainage
- 6) Weight

The style, shape, and size of the container should complement the plants grown. Small containers are best for small slow-growing plants, while fast-growing plants are better suited for large needs plenty of water, but they should not be used for cacti and succulents. containers.

Containers can be made from a wide range of materials - terra cotta, clay, plastic, or ceramic. Terra cotta pots, made of fired clay, are some of the most popular choices, with designs ranging from plain to ornate. Plants perform very well in terra cotta pots, as the porous surface allows good air exchange between the plant roots and the environment. Other clay containers (not considered terracotta) range from gray to brown in color, depending on the clay used. Clay pots can be glazed or unglazed. The glazed pots restrict air exchange but offer more design choices. Unglazed pots evaporate water faster and plants in them may need more frequent watering. Disadvantages of clay containers include their weight (especially large pots) and the chance they will chip or break.

Constructed of materials such as polyethylene, polyurethane, recycled plastic, and fiberglass, Plastic plant pot come in a variety of shapes and colors. There are various form of pots to suitable for growing plants because the pots are lightweight. Easy to move. They are the same size. It does not waste space to store, easy to clean. There is no moss surrounding the pot. Retains moisture in the planting material well; Suitable for growing plants that require high humidity. In despite of plastic pots are not porous

around like clay pots. As a result, poor ventilation and water can cause the roots of plants not to receive enough oxygen if the plant material does not drainage well. Causing the plant to rot root easily. Plastic plant pot not resistant to heat and chemicals when exposed to the sun for a long time, It is hard, crisp, and easy to break.

To grow plants outdoors, The temperature of the planting material will be higher. Professor Sompian Kasemsap and colleagues (1983) said that if using black pots to plant potted plants in the summer, the pot is placed outdoors. In full sun, the flower will immediately show signs of danger from the temperature of the pot plant material above 40 degrees Celsius. Still, if planted during the rainy season and winter, it is not dangerous because the temperature of the planter decreases. Down is not harmful to plants. Lowering the temperature of the planter can be done in two ways: Avoid using black plastic pots in the summer, or drilling more than one hole in the bottom of the pot may cause 3-4 holes.

The conclusion from the study of the above information shows that indoor planting has many factors to consider, such as the selected of plant species, factors important to plant growth, proper preparation of planting material, container type, and raw materials. Which these elements affect the health of plants.

Chapter 3

Research Methodology

3.1 Observation & Experiment

3.3.1 Shopping plants

Today, most people spend more and more time in their shelters. Refrain from being in crowded public areas due to the state of the COVID-19 pandemic. For potted planting plants inside the accommodation, buying plants to plant is not difficult because plants can order through online stores such as Lazada, Shopee, or on social media such as Facebook and Instagram, and others (Figure 3.1). The experimental author ordered plants, planted equipment through an online store, and bought some from the tree market. To obtain trees from various sources and environments. Plants purchased online will be shipped to order in different ways. They will be packaged in parcel boxes or baskets (Figure 3.2). There is stuffiness inside the box, and it spends a few days in the box. They are causing the plant to wither or be affected by transportation. Therefore, plants ordered online need to be recuperated to acclimate or take time to adapt to the new environment—primary care such as watering (not too much) or placing in a well-ventilated shade place. Refrain from changing pots immediately, which is preliminary advice from sellers, has more care details than plants purchased directly from the garden or nursery. The author had the opportunity to chat with sellers and gardeners from various sources. Inquire about the methods of cultivating each plant with different information and advice. Buying plants online will have information about plant care that can find on the page or under the plants' photo, which is general care information (Figure 3.3). The author talks to the seller or gardener to get information on how to care, such as what kind of light the plant prefers, watering, planting material, etc. That's not enough information for managing for each plant that various and different needs.

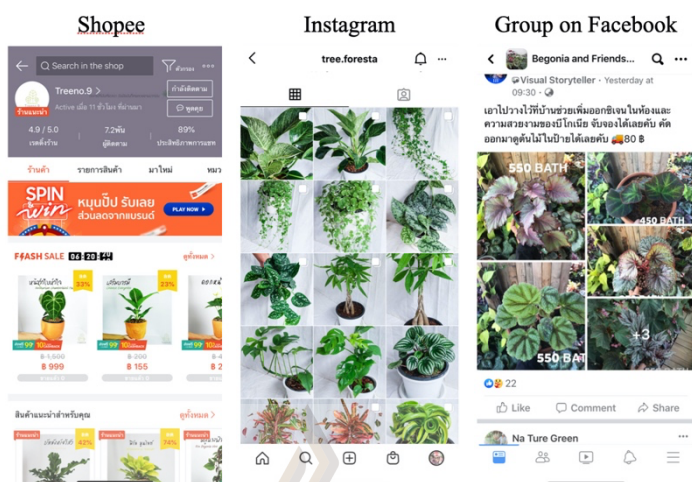


Figure 3.1 Plants shop online



Figure 3.2 Online order and delivery of plants, plants in the box and basket

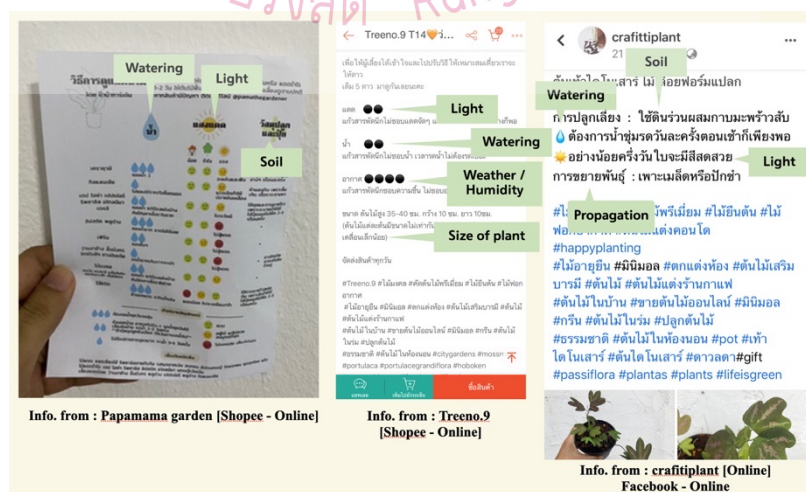


Figure 3.3 Plants requirement information from the online shop

3.3.1 Selecting plants

The author choose 25 types to grow indoors , rate in price from 20 baht to 500 baht per plant. Then try planting, follow the seller's guide, and find out more about how to plant and care for it from many media. Combining the results of planting experiments and problems encountered with the knowledge provides a framework for designing systems and equipment to help grow indoor plants more successfully. Allows plants to grow in limited spaces The selected plants are as follows:

- 1) *Epipremnum aureum*
 - 1.1) Golden Pothos
 - 1.2) Neon Pothos
 - 1.3) Manjula Pothos
 - 1.4) N-Joy Pothos
- 2) *Philodendron*
 - 2.1) *Philodendron Micans*
 - 2.2) *Philodendron Hastatum*
- 3) *Scindapsus pictus*
 - 3.1) Exotica
 - 3.2) *Argyraeus*
 - 3.3) Silver Lady
 - 3.4) Unknow
- 4) *Syngonium*
 - 4.1) Mini Allusion
 - 4.2) *Erythrophyllum*
- 5) Piper or Pepper vine
 - 5.1) *Piper ornatum*
 - 5.2) *Piper Sylvaticum*
- 6) *Begonia*
 - 6.1) *Begonia maculata*
 - 6.2) *Begonia Tamaya*
 - 6.3) *Begonia snowcap*

7) Aglaonema

7.1) Dud Unyamanee

7.2) Dud Rapgoenrapthong

7.3) Siam Aurora

8) Calathea makoyana

9) Alocasia

9.1) Amazonica

9.2) Bambino Arrow

10) Monstera sp. Karstenianum

11) Stephanian Erecta

The authors selected examples of these plants based on personal preferences and are popular indoor plants. mostly foliage Moderate level of ease of care Easy to find care information The author then collects information on how to plant and care for each plant from the website: smartgardenguide.com, YouTube channel: Wanna Pinitpaitoon, Swedish cultivar, Miki Home and Jojo Leaf.

3.1.3 Planting plants indoors to define problems

The author prepared a space for plants to be placed in an area of approximately 40x120 centimeter near the window to allow the plants to receive some natural light for the room planting experiment (Figure 3.4).



Figure 3.4 Indoor planting plants space

The author uses a variety of accessories to learn and understand how to care for indoor plants properly. For example, using a hygrometer to periodically check the humidity level in the room so that the plants get the proper humidity, the light metering device to understand the appropriate amount of light and right locate, soil moisture meter to learn an accurate watering control (Figure 3.5).



Figure 3.5 Tools for check Moist in soil / Light / Humidity / Temperature

After taking care of the plants for about 2 weeks, the plants have changed. There are different problems with plants (Figure 3.6).

10 days later

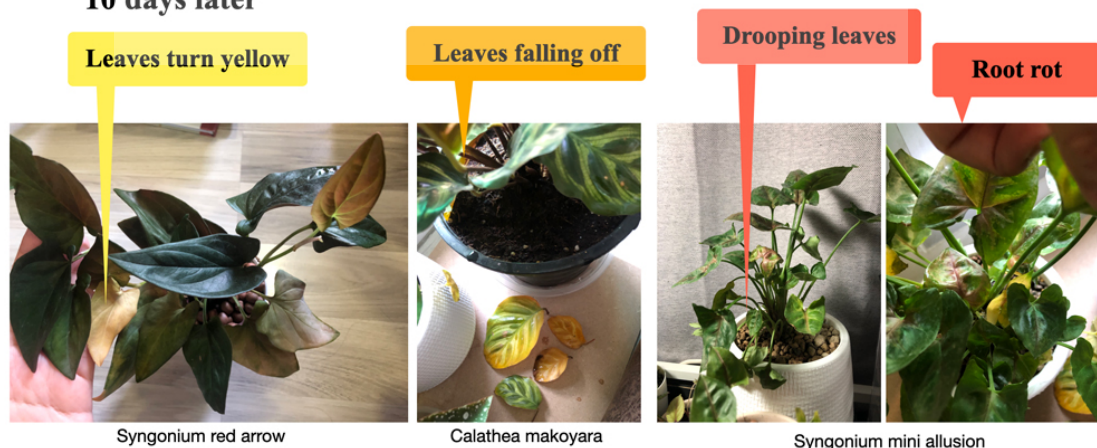


Figure 3.6 The plant shows signs of abnormalities.

1) Leaves turn yellow: After change soil mix their leaves turn to yellow, tight and wet soil that holds too much water and the author watered too much without knowing. Solve the problem by the change from soil system to water system [growing in the water vase]. They can survive but not healthy.

2) Leaves falling off : Lack of light and too much watering. Solve the problem by moving to a place with more light and reducing watering.

3) Drooping leaves and root rot : too much watering, lack of light, low humidity and air not flow. Solve the problem by after replacing new pots and soil. Its leaves turn yellow every day. Then I cut all the yellow leaves and removed them from the container. I found the roots rotten, cut all the leaves, cleaned the roots, and planted the stems in a Popper [clay balls] with water in a closed system to trap moisture.

3.2 Research information on caring indoor plants

3.2.1 Golden Pothos



Figure 3.7 Golden Pothos

Scientific Name: *Epipremnum aureum*

Common Name: Golden pothos, silver vine, taro vine, devil's vine, devil's ivy

Where To Buy: [Home & Garden Fair] Size of pot: 4"

Origin: Central America and the Caribbean , Solomon Islands

Light Requirements: medium light, well-lit but sunless / tolerate low light for long periods

Watering: Keep the potting soil lightly moist during the growing season.

Reduce watering in autumn and winter. Consider using filtered water or rainwater.

Soil: Choose well-drainage potting mix. pH: 6.1 to 6.5

Temperature: grows best between (21-32°C) avoid temperatures lower (10°C)

Fertilizer : Balanced, water-soluble fertilizer=WSF applied every 3-4 weeks when the plant is actively growing.

Humidity : Medium to high humidity, >40%.

Pruning : pinch back stems to maintain bushy growth or to control size

Propagation: Stem cuttings can be easily propagated in water or soil.

Re-Potting: Every 6 month to refresh the potting mix and avoid the plant becoming too root bound.

Diseases and Pests: Root rot and pests are more likely in an overwatered plant.

Aphids, scale, spider mites, fungus gnats, and mealybugs.

Toxicity: Toxic if ingested.

3.2.2 Neon Pothos



Figure 3.8 Neon Pothos

Scientific Name: *Epipremnum aureum* 'Bunting Lime'

Common Name: Neon Pothos

Where To Buy: [Online] Size of pot: 4"

Origin: Tropical plants

Light Requirements: Can adapt to low light but prosper in bright, indirect light throughout the year. Intense sunlight will burn the leaves, while too little sunlight will cause the leaves to turn pale green and smaller. a location near

the window where the sunlight is bright and indirect. Great for darker spaces

Watering: well-drained soil if kept uniformly moist. maintain the soil moist, but not soggy or saturated. They can tolerate the occasional missed watering. Sit in waterlogged soil, it will result in wilted and yellow leaves. This specific species likes to dry the soil before watering. Once the top 2 inches of soil has become dry you should consider watering the plant again.

Soil: Well-draining potting soil. pH: 6.1 to 6.5

Temperature: The best temperature is between 18.3°C-29.4°C. leaves may be damaged if the temperature drops below(12.8°C)

Fertilizer : Feed every other month with a plant food high in nitrogen diluted to 1/2 the recommended strength.

Humidity : grows best in high humidity [bathroom or kitchen]. Brown leaf tips can mean that the atmosphere is too dry. Lack of moisture, fill the saucer with pebbles and water.

Pruning : Aggressively trim the long vines every few months to keep your plant full and bushy. You can use the stem tip clippings to easily start new plants.

Propagation: Stem cuttings can be easily propagated in water or soil.

Re-Potting: Every 6 month to refresh the potting mix and avoid the plant becoming too root bound.

Diseases and Pests: Prone to root rot if overwatered. Spider mites and scale can occasionally be encountered.

Toxicity: Toxic to pets and people if ingested. Can also cause skin irritation on occasion.

3.2.3 Manjula Pothos



Figure 3.9 Manjula Pothos

Scientific Name: *Epipremnum aureum* Manjula

Common Name: Manjula Pothos

Where To Buy: [Plant nursery] Size of pot: 6"

Origin: Tropical plants

Light Requirements: can tolerate low light, it's best to place your Manjula Pothos where it'll receive plenty of natural light but keep it out of direct sunlight. The paler, white leaves of the plant are susceptible to strong light, which can cause them to scorch.

Watering: well-drained soil if kept uniformly moist. maintain the soil moist, but not soggy or saturated. They can tolerate the occasional missed watering / Sit in waterlogged soil, it will result in wilted and yellow leaves. This specific species likes to dry the soil before watering. Once the top 2 inches of soil has become dry, you should consider watering the plant again.

Soil: Well-draining potting soil. pH: 6 to 6.5

Temperature: The best temperature is between 21°C-32°C. leaves may be damaged if the temperature drops below(10 °C)

Fertilizer : Feed every other month with a plant food high in nitrogen diluted to 1/2 the recommended strength.

Humidity : higher humidity.

Pruning : Aggressively trim the long vines every few months to keep your

plant full and bushy. You can use the stem tip clippings to easily start new plants.

Propagation: Stem cuttings can be easily propagated in water or soil.

Re-Potting: Every 6 month to refresh the potting mix and avoid the plant becoming too root bound.

Diseases and Pests: Prone to root rot if overwatered. Spider mites and scale can occasionally be encountered.

Toxicity: Toxic to pets and people if ingested. Can also cause skin irritation on occasion.

3.2.4 N-Joy Pothos



Figure 3.10 N-Joy Pothos

Scientific Name: *Epipremnum aureum* (Linden & André) G. S. Bunting

Common Name: Pearls and Jade Pothos / N-Joy Pothos

Where To Buy: [Plant nursery] Size of pot: 4"

Origin: India

Light Requirements: Full Sun to Partial Shade / Partial or Dappled Shade

Watering: well-drained soil if kept uniformly moist. maintain the soil moist, but not soggy or saturated. They can tolerate the occasional missed watering / Sit in waterlogged soil, it will result in wilted and yellow leaves. This specific species likes to dry the soil before watering. Once the top 2 inches of soil has become dry, you should consider watering the plant again.

Soil: Well-draining potting soil. pH: 6 to 6.5

Temperature: 18°C to 29°C

Fertilizer : Feed every other month with a plant food high in nitrogen diluted to 1/2 the recommended strength.

Humidity : Maintain humidity in the 50 to 70% range.

Pruning : Only necessary to control size and shape of your plant.

Propagation: Stem cuttings can be easily propagated in water or soil.

Re-Potting: The perfect time to repot Pothos N-joy is in spring or summer.

Diseases and Pests: Prone to root rot if overwatered. Spider mites and scale can occasionally be encountered.

Toxicity: Toxic to pets and people if ingested.

3.2.5 Philodendron Micans



Figure 3.11 Philodendron Micans

Scientific Name: *Philodendron hederaceum*

Common Name: Heart leaf Philodendron / Philodendron Micans

Where To Buy: [Online] Size of pot: 4"

Origin: Central America and the Caribbean

Light Requirements: Bright, indirect light, but will tolerate lower light levels very well.

Watering: Keep the potting soil lightly moist during the growing season.

Reduce watering in autumn and winter. Consider using filtered water or rainwater.

Soil: Well-draining potting soil.

Temperature: 24°C to 27°C

Fertilizer : Balanced, water-soluble fertilizer=WSF applied every 3-4 weeks when the plant is actively growing.

Humidity : Medium to high humidity, >40%

Pruning : Only necessary to control size and shape of your plant.

Propagation: Stem cuttings can be easily propagated in water or soil.

Re-Potting: Every 1 years to refresh the potting mix and avoid the plant becoming too root bound.

Diseases and Pests: Root rot and pests are more likely in an overwatered plant.

Aphids, scale, spider mites, fungus gnats, and mealybugs.

Toxicity: Toxic if ingested.

3.2.6 **Philodendron Hastatum**



Figure 3.12 Silver Sword Philodendron.

Scientific Name: *Philodendron hederaceum*

Common Name: Silver Sword Philodendron.

Where To Buy: [Online] Size of pot: 6"

Origin: Tropical Asia

Light Requirements: Bright, indirect light. Avoid excessive direct sunlight.

you can place a location that receives bright light. If placed in a location lacking sufficient light the plant loses its color, including the leaf veins and can eventually die.

Watering: it is important to water frequently enough to keep the soil evenly moist but not soggy, watering when the surface begins to dry. Reduce watering significantly in winter.

Soil: Lightweight, well-draining potting mix. [well-aerated soil that drains quickly too much moisture, which can lead to rot problems and even plant death.] [25% Fir Bark + 25% Perlite +30% Coconut Coir +10% Horticultural Charcoal +10% Worm Castings] lightweight and does not have a tendency to retain too much water. Don't use soil that is heavy like straight potting soil as it has a tendency to remain too wet, creating problems with rot.

Temperature: 18°C to 27°C grows best in a warm environment.

Fertilizer : Use a well-balanced liquid fertilizer or a liquid blend for houseplants and apply every two to four weeks at half-strength. / flushing the soil every few months to wash any salts from it. This is as easy as taking the entire container to your sink and allowing the water to run slowing through the soil for about five minutes.

Humidity : Moderate to high humidity levels are required, ideally greater than 50% humidity. Mist the plant's foliage once or twice weekly.

Pruning : Simply wipe the blades off with rubbing alcohol or a household disinfectant and you are ready to start snipping.

Propagation: Gently divide the rhizome when repotting in springtime.

Re-Potting: Only repot the plant into a container that is one size larger than the present one.

Diseases and Pests: You can easily treat a spider mite problem by spraying the top and undersides of leaves with an insecticidal soap or neem. Always follow directions on mixing amounts and frequency of use.

Toxicity: Non-toxic. Safe for humans and pets.

3.2.7 *Scindapsus pictus*



Figure 3.13 Exotica



Figure 3.14 Argyraeus



Figure 3.15 Silver lady



Figure 3.16 Unknow

Scientific Name: *Scindapsus*

Varieties: *Scindapsus pictus* 'Exotica', 'Argyraeus', 'Silver lady', 'Unknow'

Where To Buy: [Online] Size of pot: 6"

Origin: Warm and humid regions of southeastern Asia South east Asia, Bangladesh, Borneo, the Philippines, Java and Sumatra

Light Requirements: Bright, indirect light. Quite tolerant to lower light, but can start to lose its characteristic leaf markings.

Watering: Water once the top 2-3 inches of soil is dry. Will tolerate under watering, but much less tolerant of overwatering. [too wet due to problems with root rot.]

Soil Choose a nutrient-rich, well-draining potting mix. Any good quality houseplant potting mix will be suitable. [excellent drainage]

Temperature: 18°C to 29°C for best growth.

Fertilizer : Balanced, water-soluble fertilizer applied monthly through the growing season.

Humidity : > 40% humidity. Consider getting a digital hygrometer to monitor humidity if your plant is getting brown tips.

Pruning : Only necessary to control size and shape of your plant.

Propagation: Propagate stem cuttings in water or moist potting mix.

Re-Potting: Repot every 1-2 years at the start of the growing season.

Diseases and Pests: Prone to root rot if overwatered. Spider mites and scale can occasionally be encountered.

Toxicity: Toxic to pets and people if ingested. Can also cause skin irritation on occasion.

3.2.8 Syngonium Mini Allusion



Figure 3.17 Mini Allusion

Scientific Name: *Syngonium podophyllum*

Common Name: Arrowhead plant / Arrowhead Vine 'Mini Allusion'

Where To Buy: [Online] Size of pot: 5"

Origin: Brazil, Bolivia, Ecuador, and Mexico, South America, West Indies

Light Requirements: indirect light / They are low light tolerant houseplants and will grow virtually anywhere in your home. / they will grow faster and maintain their vibrant coloring and markings if grown in medium to bright indirect light. Direct sun will scorch their leaves. If foliage loses its color and

becomes lighter, and the leaves are spaced further apart move it to a location that is slightly brighter than the original. It's best to increase gradually the plant's light exposure so you don't burn the leaves.

Watering: The soil mix should be kept lightly moist during spring | summer and slightly drier during the fall and winter months. Don't let it become completely dry. Water moderately throughout the growing season and reduce watering during cooler months

Soil: well-draining pH: 5.5 to 6.5

Temperature: Arrowhead Vines will grow in 15°C to 29°C. They do not like the temps to drop below 10°C

Fertilizer : Add water-soluble granular fertilizer or Osmocoat or worm casting little by little, once a month before winter

Humidity : Creating a humid environment for the plant is as easy as misting the foliage with water two to three times weekly. set the container on a stone-filled tray that catches the irrigated water, as well as misting.

Pruning : Aggressively trim the long vines every few months to keep your plant full and bushy. You can use the stem tip clippings to easily start new plants.

Propagation: Cut sections of stem containing root nodes and place them in clean water to grow roots. If you see that your plant has developed aerial roots on the stem, you can be certain that stem section will root easily. [Cleaning your pruning tool blades is as easy as wiping them off with rubbing alcohol]

Re-Potting: Repot every 1-2 years at the start of the growing season.

Diseases and Pests: These hardy plants have no pests or disease problems when cared for properly. Maintain a moderate watering schedule and provide the right type of substrate to prevent: Rotting of plant roots / Bacterial leaf spot / Colonies of Spider mites/ Scale on plants / Aphids / Sap sucking Mealybugs

Toxicity: toxic to dogs, cats, horses, and people.

3.2.9 Syngonium Erythrophyllum



Figure 3.18 Arrowhead plant

Scientific Name: Syngonium Erythrophyllum

Common Name: Arrowhead plant , Syngonium red arrow

Where To Buy: [Online] Size of pot: 4"

Origin: The tropical rain forests of Southern Mexico as well as South America.

Light Requirements: Medium to Low light [direct sunlight will make leaf burn]

Watering: Normal to high watering 1-2 time in a week (in summer) / Plant in low to medium sunlight > let dry out between watering and water only when top 3cm are dry to touch

Soil: Choose a nutrient-rich, well-draining potting mix. :Coco peat , Perlite and cow dung manure. [excellent drainage] pH: 5.5 to 6.5

Temperature: Winter (16-18°C) and (20-30°C) for best growth.

Fertilizer : feed your plant with dilute, water-soluble fertilizer. in spring and summer seasons / a slow-releasing fertilizer, switch to a 6-month routine / [Try not to fertilize during the winter season and wait for the plant to come of dormancy.]

Humidity : Very high > 40% humidity. Mist the plant lightly but frequently 2-3 time in a day

Pruning : Only necessary to control size and shape of your plant.

Propagation Propagate stem cuttings in water or moist potting mix.

Re-Potting: Repot every 1-2 years at the start of the growing season.

Diseases and Pests: Prone to root rot if overwatered. Spider mites and scale can occasionally be encountered.

Toxicity: Toxic to pets and people if ingested. Can also cause skin irritation on occasion.

3.2.10 Piper Ornatum, Piper Sylvaticum



Figure 3.19 Piper Ornatum



Figure 3.20 Piper Sylvaticum

Scientific Name: *Piper ornatum* N.E.Br. as shown in Figure 3.10 (Left) , *Piper sylvaticum* as shown in Figure 3.10 (Right)

Common Name: Celebes Pepper as shown in Figure 14

Where To Buy: [Online] Size of pot: 4"

Origin: O. Sulawesi. Peru, Malaysia, Southeast Asia, India, Burma

Light Requirements: Most species prefer bright scattered light (west or east window), however, Piper should be shaded from direct sunlight.

Watering: Pour moderately soft water at room temperature, the soil between watering should slightly dry out. However, the substrate must not dry out in great depth, it can lead to topple and leaf fall.

Soil: well drained fertile soil with neutral reaction is suitable. pH: 5.5 to 6.5

Temperature: 16°C to 24°C Most species do not like sudden temperature fluctuations.

Fertilizer : From May to September 1 every 2 weeks with liquid fertilizer.

Humidity : The plant should be sprayed daily, put in a wet pebble.

Pruning : should be done only to remove damaged and diseased leaves.

Propagation Propagate stem cuttings in water or moist potting mix.

Re-Potting: Use a soil based potting mixture. Piper have fairly small root systems and should not be planted in needlessly big containers.

Diseases and Pests: spider mites, thrips, scale insects.

Toxicity: -

3.2.11 Begonia maculate , Begonia Tamaya, Begonia snowcap



Figure 3.21 Begonia Maculata



Figure 3.22 Begonia Tamaya



Figure 3.23 Begonia Snowcap

Scientific Name: Begonia Maculata , Begonia Tamaya, and Begonia Snowcap

Common Name: Polka Dot Begonia ,

Where To Buy: [Online] Size of pot: 4”

Origin: Brazil

Light Requirements: Bright, indirect light. Higher light levels will promote

strong growth and blooms, but avoid direct sunlight.

Watering: Keep the soil generally moist, letting the top half inch of soil dry out between watering. Will not tolerate soggy soil.

Soil: A light houseplant potting mix is ideal. Add perlite if drainage is insufficient. pH: 5.5 to 6.5

Temperature: 26°C - 34°C air flow.

Fertilizer : Balanced, water-soluble fertilizer applied every 2-4 weeks when the plant is actively growing.

Humidity : High humidity is important. > 45% ideally.

Pruning : should be done only to remove damaged and diseased leaves.

Propagation Propagate stem cuttings in water or moist potting mix.

Re-Potting: Annual repotting in spring will help greatly.

Diseases and Pests: High humidity and overwatering can cause powdery mildew, botrytis, bacterial leaf spot, stem and root rot. Whitefly and mealybugs are sometimes a problem, but easily dealt with.

Toxicity: Toxic to pets and people if ingested.

3.2.12 *Aglaonema* dud Unyamane, dud Rapgoenraphthong, Siam Aurora



Figure 3.24 Dud Unyamane



Figure 3.25 Dud Rapgoenraphthong



Figure 3.26 Siam Aurora

Scientific Name: *Aglaonema* sp.

Common Name: Chinese Evergreen, Dud Unyamanee, Dud Rapgoenraphthong and Siam Aurora

Where To Buy: [Plant nursery] Size of pot: 4"

Origin: Tropics and subtropics of Asia.

Light Requirements: *Aglaonema* is the darker the leaves and stalks, the less light is needed. a bright room with the plant sitting in a shaded spot is best. Avoid direct sunlight.

Watering: Keep the soil generally moist, letting the top half inch of soil dry out between watering

Soil: A peat based potting soil mixed with part perlite or sand to improve drainage is ideal or any other well-draining potting mix. pH: 5 to 6.5

Temperature: 13°C -27°C

Fertilizer : Osmocote 15-15-15 monthly

Humidity : Average to high room humidity is needed.

Pruning : Prune back at least twice per year to maintain compact growth.

Propagation These are best propagated by dividing the root with a few stalks and leaves attached during spring and summer.

Re-Potting: Repot every few years, to allow the plant more room to continue growing.

Diseases and Pests: aphids, mealy bugs, and spider mites

Toxicity: Toxic to cats, dogs and horses.

3.2.13 *Calathea makoyana*



Figure 3.27 Peacock Plant

Scientific Name: *Calathea makoyana* (E.Morr.) E.Morr.

Common Name: Peacock Plant, Cathedral Windows, Brain Plant

Where To Buy: [Plant nursery] Size of pot: 7"

Origin: Tropics and subtropics of Asia.

Light Requirements: Bright, indirect light. Avoid direct sunlight.

Watering: Maintain moist soil. Water once the surface of the soil starts to dry.

Soil: Well-draining general-purpose houseplant potting mix. pH: 5 to 6.5

Temperature: 18°C - 30°C for best growth.

Fertilizer : Use liquid or water soluble fertilizer made up at no more than half strength and apply every 2-4 weeks during the growing season. NPK 3-1-2 is perfect, but a balanced preparation is normally fine.

Humidity : 60% humidity. High humidity is really important to keep your peacock plant healthy. Using a digital hygrometer to monitor humidity is a great idea.

Pruning : *Calathea* doesn't need much in terms of pruning. Remove old leaves and pinch back to maintain compact growth. As the leaves age, they will periodically yellow or brown and then die. Trim off dead leaves with a pair of sharp, sterilized scissors, cutting them off where they join the main stem or at the soil level.

Re-Potting: Repot every few years, to allow the plant more room to continue

growing.

Diseases and Pests: aphids, mealy bugs, and spider mites

Toxicity: Non-toxic. Safe for humans and pets.

3.2.14 *Alocasia Amazonica*, *Alocasia Bambino Arrow*



Figure 3.28 Amazonica

Figure 3.29 Bambino Arrow

Scientific Name: *Alocasia Amazonica* Polly

Common Name: *Alocasia Amazonica* and *Bambino Arrow*

Where To Buy: [Online] Size of pot: 6"

Origin: Hybrid of *Alocasia longiloba* x *Alocasia sanderiana*. (Parent plants are from tropical Asia)

Light Requirements: Bright, indirect light. Avoid excessive direct sunlight. a location that receives bright light. If placed in a location lacking sufficient light the plant loses its color, including the leaf veins and can eventually die.

Watering: it is important to water frequently enough to keep the soil evenly moist but not soggy, watering when the surface begins to dry. Reduce watering significantly in winter.

Soil: Lightweight, well-draining potting mix. [well-aerated soil that drains quickly too much moisture, which can lead to rot problems and even plant death.] retain too much water. Don't use soil that is heavy like straight potting soil as it has a tendency to remain too wet, creating problems with rot.

Temperature: 18°C - 27°C grows best in a warm environment. / tolerates warm conditions. below 15°C the plant can go into complete dormancy and

the foliage can die to the ground.

Fertilizer : Use a well-balanced liquid fertilizer or a liquid blend for houseplants and apply every two to four weeks at half-strength. / flushing the soil every few months to wash any salts from it. This is as easy as taking the entire container to your sink and allowing the water to run slowing through the soil for about five minutes.

Humidity : Moderate to high humidity levels are required, ideally greater than 50% humidity. Mist the plant's foliage once or twice weekly.

Pruning : Simply wipe the blades off with rubbing alcohol or a household disinfectant and you are ready to start snipping.

Propagation: Gently divide the rhizome when repotting in springtime.

Re-Potting: Only repot the plant into a container that is one size larger than the present one.

Diseases and Pests: You can easily treat a spider mite problem by spraying the top and undersides of leaves with an insecticidal soap or neem. Always follow directions on mixing amounts and frequency of use.

Toxicity: Non-toxic. Safe for humans and pets.

3.2.15 *Monstera sp. Karstenianum*



Figure 3.30 *Monstera sp. Peru*

Scientific Name: *Monstera Karstenianum*

Common Name: *Monstera sp. Peru*

Where To Buy: [Online] Size of pot: 4"

Origin: Sulawesi [tropical forests, scandent] , Peru, South of America,

Light Requirements: indirect light, also known as filtered sun. can take about half an hour of direct sunlight

Watering: Like moist soil you should never let the soil dry out all the way. you'll be watering your plant twice a week.

Soil: Lightweight, well-draining potting mix

Temperature: 18°C - 27°C grows best in a warm environment

Fertilizer : Use a balanced fertilizer like a 15-15-15 or a blooming fertilizer like a 7-9-5. Discontinue feeding during the winter.

Humidity : humidity is an important factor.

Pruning : Only necessary to control size and shape of your plant.

Propagation: stem cutting needs be between six and eight inches in length. cut above a leaf node and it should have about two leaves on it. Water it when the soil's dry and keep it away from bright direct light. Within three weeks, the stem cutting should start rooting.

Re-Potting: Only repot the plant into a container that is one size larger than the present one.

Diseases and Pests: Mealybugs, brown scales, spider mites. Use insecticidal soap. It's an all-natural pesticide that kills pests. / use 70% isopropyl alcohol and a cotton swab to rid your plant of small pest infestations.

Toxicity: Non-toxic. Safe for humans and pets.

3.2.16 *Stephania Erecta*



Figure 3.31 *Stephania Erecta*

Scientific Name: *Stephania Electa*

Common Name: *Stephania Electa*

Where To Buy: [Online] Size of pot: 4"

Origin: Thailand

Light Requirements: Bright light, Diffused sunlight or indirect bright light is best.

Watering: Due to the gritty well-draining nature of the soil mix required for this, and depending on your lighting condition, water generally 1-2 times a week - but allow soil to dry between waterings. Do not to over-water the plant or let it sit in soggy bottom!

Soil: well draining soil mixture. A gritty mix with good balance of humidity, porousness & nutrients.

Temperature: 25°C - 30°C grows best in a warm environment

Fertilizer : Use a balanced fertilizer like a 15-15-15

Humidity : Enjoys airy condition & some misting from time to time.

Pruning : Only necessary to control size and shape of your plant.

Propagation: -

Re-Potting: Only repot the plant into a container that is one size larger than the present one.

Diseases and Pests: spider mites, Shrunk bald

Toxicity: Non-toxic. Safe for humans and pets.

3.3 Classification of plants

The authors divided indoor plants into three groups. The plants in each group can be planted and maintained in the same way. They are grouped according to plant needs, humidity, light, soil type (Figure 3.32);

Group A: Tropical evergreen forest plants like moderate to high humidity prefer partial shade and soil well-drainage.

Group B: Tropical rainforest plants prefer high humidity, prefer indirect sunlight, and planting material well-drainage and keep moist but not wet.

Group C: Deserts and dry regions plants like full sun, warm climates, fast soil drainage, and low water requirements.

The author used this flowchart (Figure 3.33) to guide the further development of tools for the care of each group of plants.

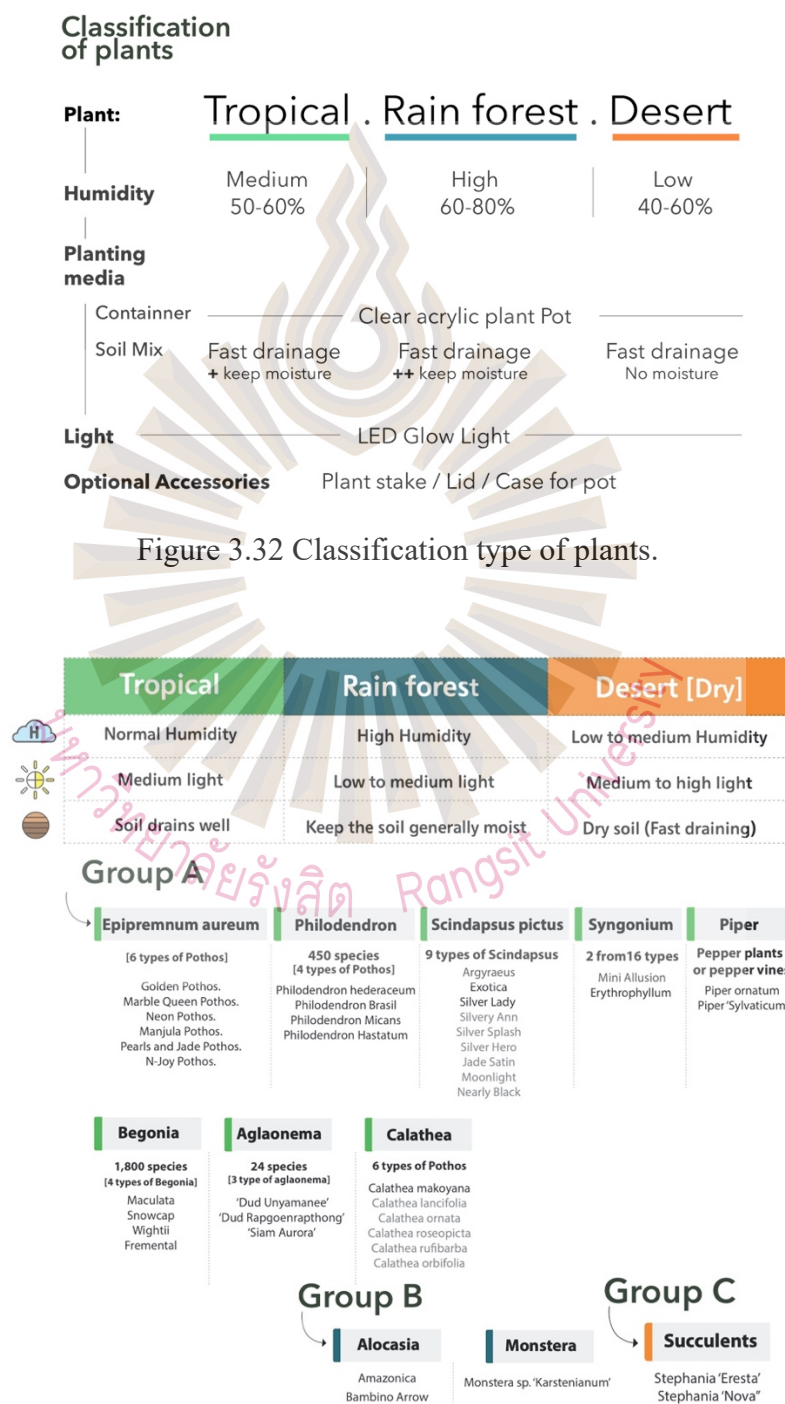


Figure 3.33 Categorize plants and group them.

3.4 Design Progress

3.4.2 Sketch idea and prototype of plant pots

First sketch idea and prototype to create a plant pot. The idea is to develop a plant pot that can attach the components or accessories for taking care of each plant, such as the pebble tray below, the plant pole to support the climbing plant, the plant pot holder can attach, LED to grow light. (Figure 3.36)

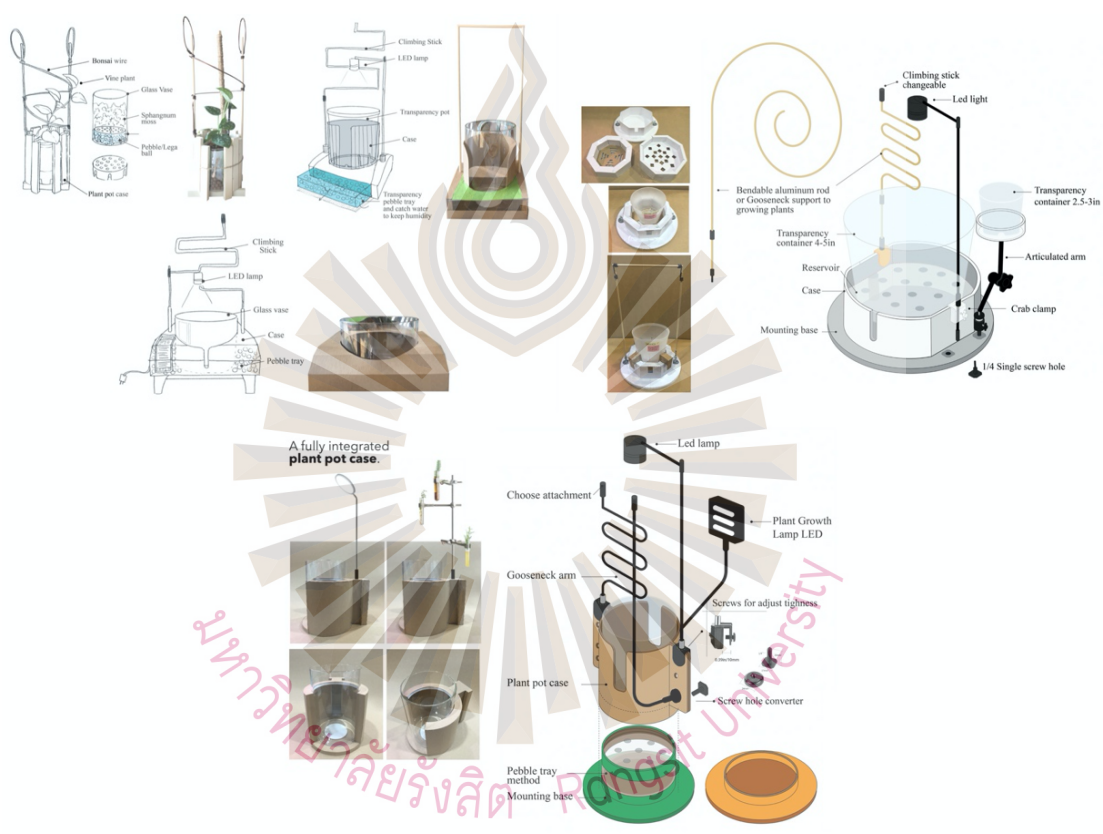
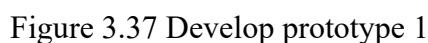


Figure 3.36 Sketch ideas in concept of user's potted accessory mounting stand which can support various plant care equipment fully integrated.

All of each plant pot prototypes. The author tries to;

- 1) Integrate a self-watering system into a plant pot.
- 2) Add moisture storage into the plant pot and develop a pot's shape to suit small space.

- The author's plants grow well. The soil is not wet, does not develop mold on the surface, and only uses water 200ml. once / 1-2 weeks. So, It's work, and It's will be a part of the plant care system.



As shown in the graphic (Figure 3.38), there are pots for evergreen plants, rainforest plants, desert & succulents plants, and an extra one for growing semi-hydro

plants. It comes complete with accessories such as a wooden box frame, a small terrarium lid, and a decorative vacuum sticker on the plant pot body.

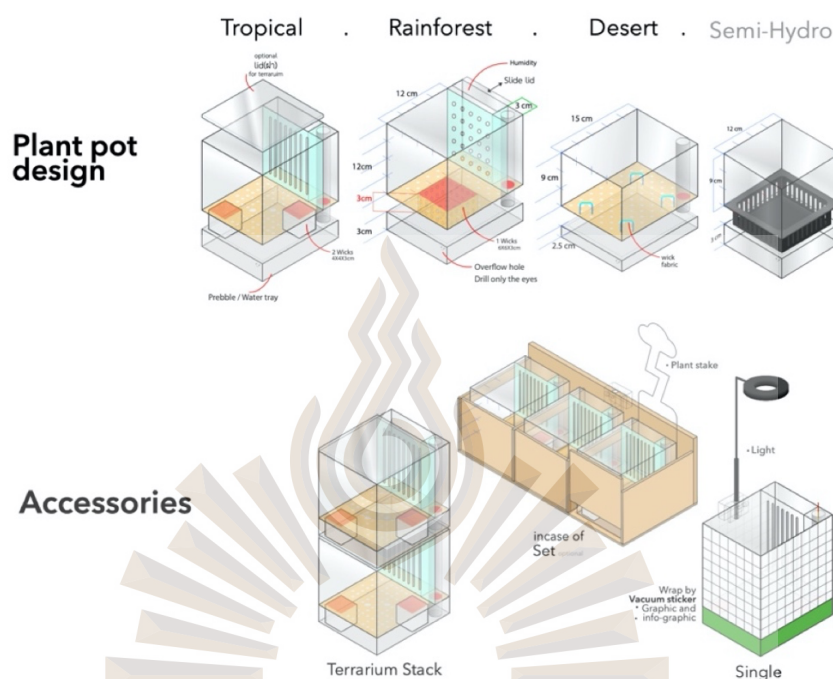


Figure 3.38 Develop prototype 2

3.4.4 Indoor plant care system

From the plant care card to the design process of plant pots and accessories. Therefore, Thus the author design the system for simply caring for the indoor plants in 4-steps;

- 1) People choose plants from anywhere or from my product launches on social media.
- 2) Then get a plant pot set with the details below.
- 3) Access the application by scanning the QR code from the pot.
- 4) Assemble the plant pot and follow the instructions in the application. And in optional, the user may purchase additional accessories. Let's grow the plant!

Chapter 4

Research Results

4.1 Cultural requirements care of indoor plants

A first suggestion for the growers is that the plants in the shady area are indoor plants since they need low or indirect light whereas those at the front, which is directly exposed to the sunlight, are outdoor plants. (Figure 4.1) shows an example of a plant nursery that applies to indoor cultivation under shading areas and the outdoors plant can be found in the area of direct light.



Figure 4.1 A nursery where trees are arranged according to the planting types

The authors selected 25 plants as in Table 4.1 that can be planted in a room defined as a shaded area. Based on recommendations from various social media articles, the abbreviation and code numbers of the guidelines for care treatment (Pennisi, 2020) are detailed below;

L = Light

- 1) Sunny light areas: At least 4 hours of direct sun

2) High-light areas: Over 200 ft-c, but not direct sun

3) Medium-light areas: 75 ft-c to 200 ft-c

4) Low-light areas: 25 ft-c to 75 ft-c

T = Temperature

1) Cool: 10°C at night and 18.3°C during the day

2) Average: 18.3°C at night and 24°C during the day

3) Warm: 21°C at night and 29.4°C during the day

H = Relative Humidity

1) High: 50% or higher

2) Average: 25% to 49%

3) Low: 5% to 24%

W = Watering

1) Keep the soil mix moist

2) Surface of the soil mix should dry before re-watering

3) The soil mix can become moderately dry before re-watering

S = Suggested Soil Mix for specific ingredients, refer to the various growing mixes in “Soil/Growing Medium.” The soil mixes are keyed as follows:

1) Flowering house plants

2) Foliage plants

3) Succulents and cacti

Table 4.1 List of Indoor plants and their cultural requirements

Botanical Name	Common name	Cultural Care				
		L	T	H	W	S
Epipremnum aureum	Golden Pothos	3	3	2	2	2
	Neon Pothos	3	3	2	2	2
	Manjula Pothos	3	3	2	2	2
	N-Joy Pothos	3	3	2	2	2
Philodendron	Philodendron Micans	4	3	2	2	2
	Philodendron Hastatum	3	3	2	2	2
Scindapsus pictus	Exotica	3	3	2	2	2
	Argyraeus	3	3	2	2	2
	Silver Lady	3	3	2	2	2
	Unknown	3	3	2	2	2
Syngonium	Mini Allusion	3	2	1	2	2

Table 4.1 List of Indoor plants and their cultural requirements (cont.)

Botanical Name	Common name	Cultural Care				
		L	T	H	W	S
Piper or Pepper vines	Erythrophyllum	3	3	1	2	2
	Piper ornatum	3	3	1	2	1
	Piper Sylvaticum	3	3	1	2	1
Begonia	Maculata	2	2	1	2	3
	Fremental	2	2	1	2	3
	Snowcap	2	2	1	2	3
Aglaonema	Dud Unyamane	2	3	2	2	2
	Dud Rapgoenraphthong	2	3	2	2	2
	Siam Aurora	2	3	2	2	2
Calathea	Calathea makoyana	2	3	2	2	2
Alocasia	Amazonica	3	3	2	2	2
	Bambino Arrow	3	3	2	2	2
Monstera	Monstera sp. 'Karstenianum'	2	3	2	2	2
Stephania	Stephania 'Erecta'	1	3	2	2	3

4.2 Experimental results

4.2.1 Survive condition of plants

In the experiment, three groups of indoor plants were classified with respect to the cultural requirements of the plants that survive them.

1) Group of Epipremnum aureum, Scindapsus pictus, and Philodendron, well known in the planting and care group close to the pothos, can adapt and grow well within the room.

2) Group of Alocasia can be grown indoors but must be controlled with careful humidity and watering, and the leaf will burn if exposed to direct sunlight.

3) Syngonium got yellow leaves and died due to over-watering and improper humidity in the room.

4) The Aglaonema, Calathea, Begonia group grew well on the balcony as they prefer the bright light and airy. If planted in the room, their leaves would be yellow and falling, respectively.

5) Cactus & succulent plants were planted in a room with low light so the stems stretched for light. They were transplanted to a well-lit balcony to allow the plants to grow.

Regarding preliminary plant changes over 2 months, the authors found problems such as root rot due to over-watering and the container does not drain, yellowing of leaves due to insufficient lighting and soil too wet, and withered and not growing leaves pale, yellow, and fall due to improper mix of planting materials.

Based on the above cultural requirements, the authors researched additional care information, inquired an expert on planting or observing plants both indoors and outdoors, as well as gathered information from a variety of sources such as research articles, books, and YouTube videos to fully understand the indoor plants' care and solutions and to organize a new care regimen for each plant. One of the most important factors for planting is sunlight, therefore, it is crucial to understand the position of lighting requirements for indoor plants. A different type of plant requires a different lighting density. A suggestion of the density of light is (Figure 4.2) illustrating zones of the bright, medium, and low light in a room. It is important to determine what kind of light the plants need to ensure that they expose to a balanced amount of light. The plants can be “conditioned” to different light levels, but care must be taken when adjusting their position by observing for the first few weeks because a sudden change in light levels can cause the plants to shock and wither (Léon & George, 2019).

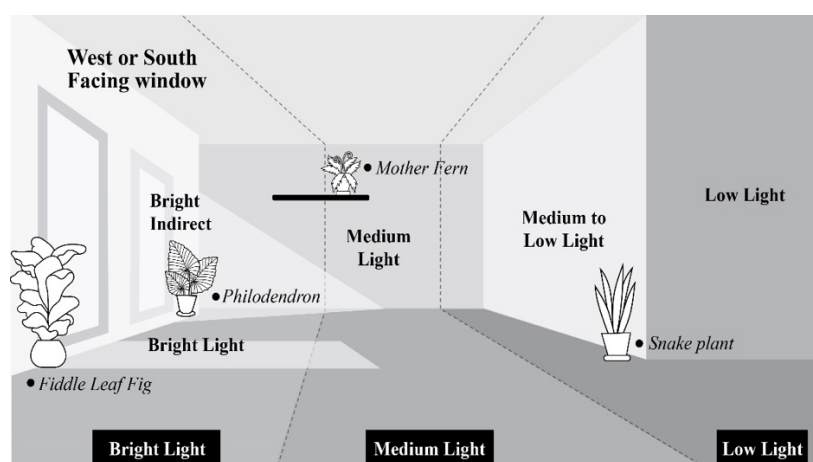


Figure 4.2 Position of lighting requirement for indoor plants

4.2.2 Potting mixture

A suitable soil mixture for indoor plants is of interest. The compositions of the mixture for potting are explored and listed below.

Water: The medium must retain the right amount of moisture to nourish the plant during watering.

Air: There must be sufficient gas exchange for the roots to breathe.

Fertility: The plant must be able to extract enough nutrients from the soil to survive and grow.

Anchoring: The soil must be sufficiently structured for supporting the root growth.

Moreover, the soil must compose three factors; soil builders, aeration and drainage, and nutrients in which the ingredients of each factor are summarized and shown in Table 4.2. It should be mentioned here that the growers can choose suitable ingredients that support the required factors. A suggestion for suitable ingredients that fit each plant will be summarized in the final section of this study.

Table 4.2 Potting soil Ingredients

Soil builders	Aeration & Drainage	Nutrients
Sphagnum moss	Perlite	Worm casting
Peat moss	Pumice	Cow manure
Coco coir	Vermiculite	Leaf composes
Loam soil	Sand	
	coco chips	
	Bark	
	Charcoal	
	Clay balls	

Source: Courtney, 2020b

4.2.3 Watering

The Evaluating the Efficiency of Wicking Bed Irrigation Systems for Small-Scale Urban Agriculture by Semananda et al. in 2016 was applied as a concept and findings for the design of the watering system in the pots to help control the water content and optimal moisture retention from the underground and to reduce root rot from over-watering. The wick bed systems (Figure 4.3) illustrating the concept ideas of the storage compartment of humidity.

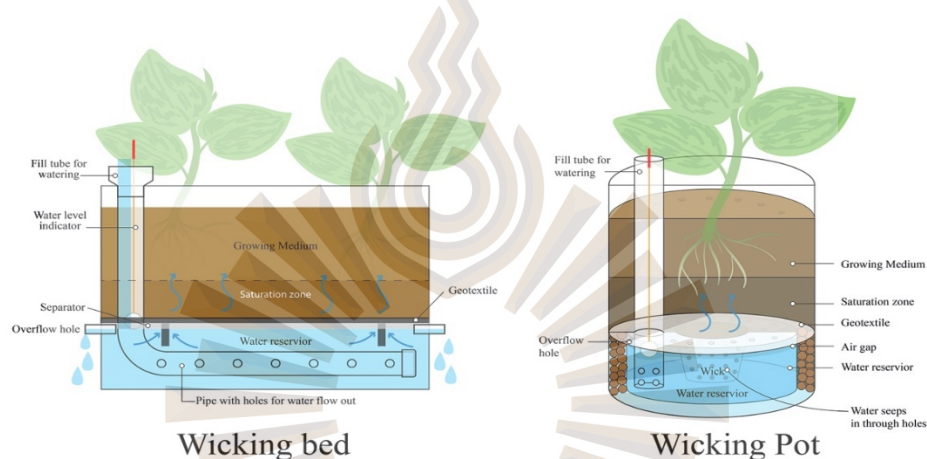


Figure 4.3 Wick bed system (left) and wick pot system (right)

The authors developed the wick bed system aiming to maintain the moisture in the pot. A compartment for moisture keeper was assembled at the back of the pot (Figure 4.4). It was designed based on the divided sections of an aquarium tank. The moisture keeper will be filled with sphagnum moss, which can absorb and maintain the moisture for the soil.

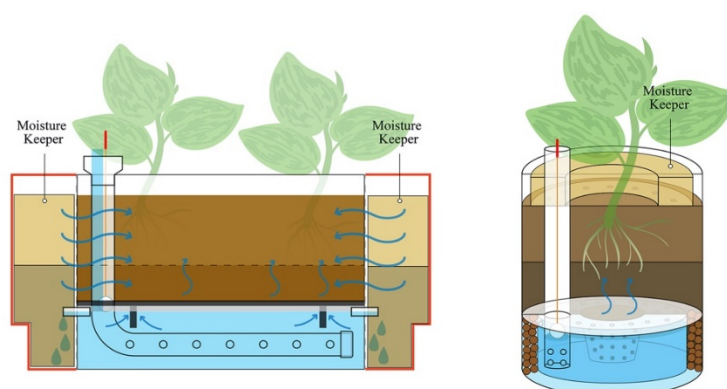


Figure 4.4 The idea of moisture keeper in the pot

The plants were categorized into groups based on their origin, humidity, light, watering, and soil mix for developing the plant pots following the needs of the plants as shown in Table 4.3 (Davision, 1914).

Table 4.3 Classification of the plant according to basic needs for proper care

Origin	Humidity	Light			Potting mix
		Type of light	Light level (ft-c)	Location	
Tropical: Evergreen Forest	Normal 50-60%	Indirect sunlight	75-150	South and east windows and west windows that do not receive direct sun.	Soil drains well
Tropical: Rain Forest	High 60-80%	Low to medium	25-75	Northern windows, Center of a room, a hallway or an inside wall.	Keep the soil generally moist
Desert:	Low 40-50%	Direct sunlight	150-1000	South-East, West window, Outdoor	Dry soil (Fast draining)

4.3 Design the plant care card

“Plant care card” and “Plant tag” were designed to provide simple plant maintenance information (Figure 4.5), by taking into account the necessary and specific information for indoor plants and the simple and complete communication formats. The authors also designed symbols for easier understanding and are more user-friendly. The details on the front of the card include a picture of the plant and its scientific name, common name, origin, brightness level, and similar care plant family names. The back of the card shows the detail about watering, soil used, plant maintenance, and fertilization and a small tag is to remind or provide short information. The seller can attach the plant care card to the plant or the growers can take notes of their plant care by themselves. The photos of the plant care card (Figure 4.6).

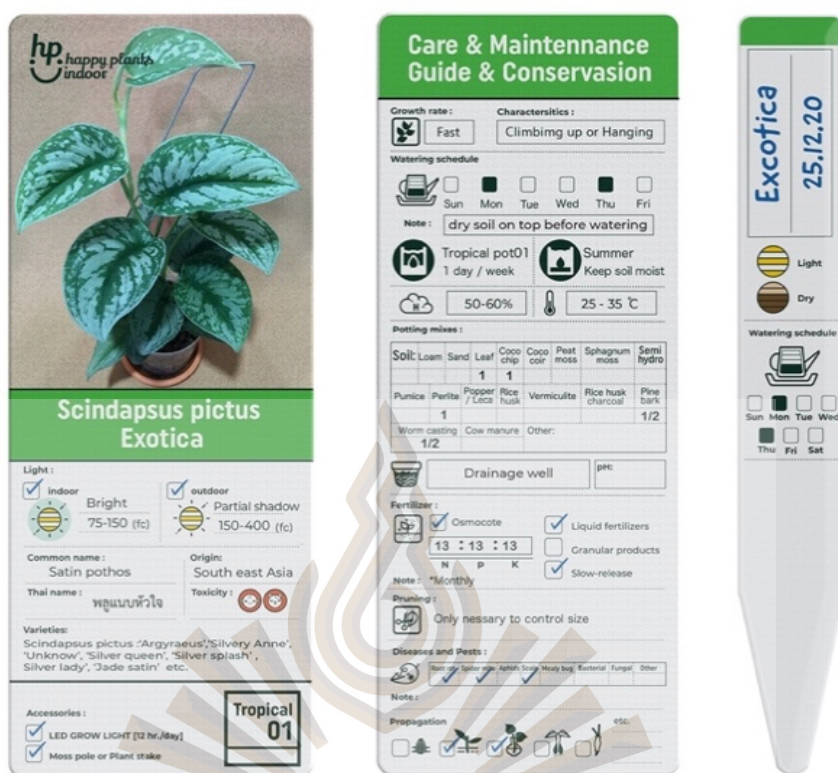


Figure 4.5 Plant care cards; left is the information in the front, the middle is the information in the back of the card, and the plant tag that provides a shortened version of the information.



Figure 4.6 Plant care cards and plant tag usage

4.4 System inside the plant pots

The authors selected transparent acrylic to design the pots for easily observing soil changes and root growth. The soil's dryness and the moisture inside the soil can also be checked before watering to properly control the amount of water so the plants will not die from root rot.

To design a plant pot that can provide optimal care for each plant, the authors were inspired by a fish tank with separated parts inside. Therefore, the inside of the pot is divided into parts as follows; a part filled with a fabric wick for the self-watering system at the bottom (Figure 4.3), a compartment different in size for each model for a planting material that draws a different amount of water from the bottom to the soil, a separated sheet between the reservoir and the planting material, a compartment at the back of the pot for storing moisture keeping materials such as sphagnum moss, a small lid to prevent a quick moisture leak, drill holes between the walls that allow the moisture to flow into the soil, and a pipe for watering from the bottom. The components of the pot and the system inside are (Figure 4.7).

The accessories' sketch ideas such as a wooden box frame, a small terrarium lid, and a vacuum decorative sticker on the pot's body (Figure 4.8).

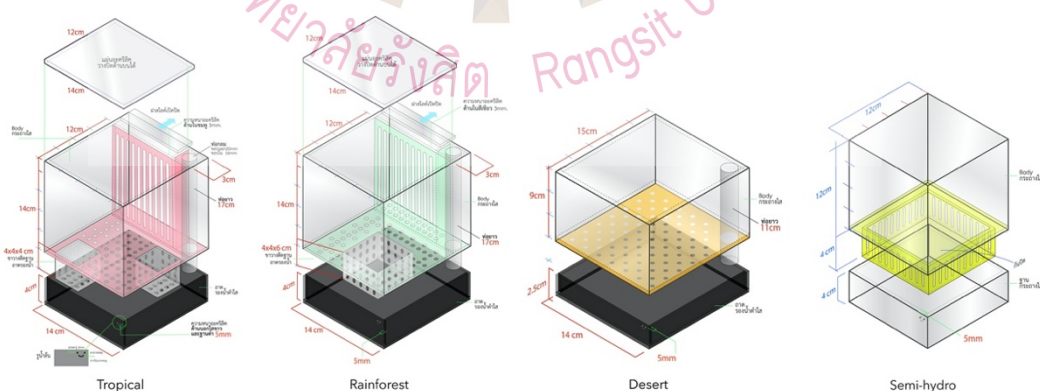


Figure 4.7 Component of pot and system inside of each plant pot

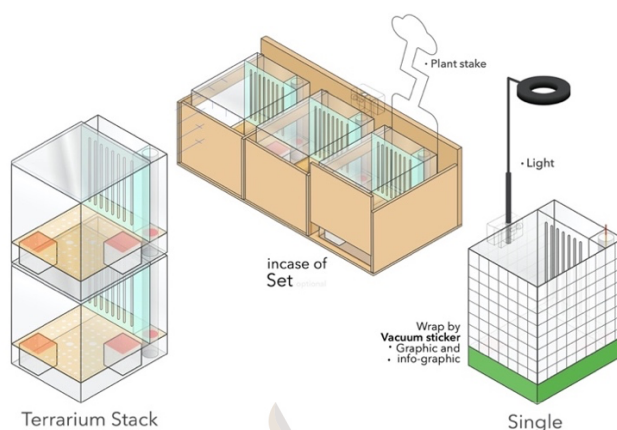


Figure 4.8 Accessories sketch idea

This section describes the functionality of each type of plant pot in which the exterior shape of the pots is similar but the internal system is different, as detailed in each model below.

1) Tropical-01 model for evergreen plants that prefer normal humidity and require well-drained soil and light to partial shade. This pot model comes with two small fabric wicks to draw water, one in the front and another in the back, and drainage holes to control the water level. This pot model can water only 250 ml from the top of the soil or through the pipe down to the bottom by not over 450 ml. The water is slow drawn up into the soil, so the user does not need to often water, (Figure 4.9).

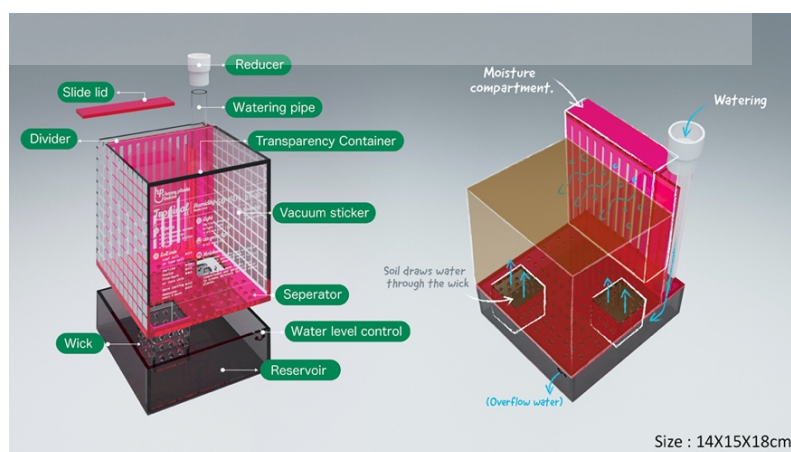


Figure 4.9 Tropical-01 model for evergreen plants

2) Tropical-02 model for a tropical rainforest plant. The difference between this pot model and the first one is a bigger fabric wick so more water can be drawn upward, a faster moisture keeper compartment in which moisture material has more holes to draw and release more moisture than the tropical-01 model. This pot model is proper for the moisture-loving plants and the soil mixture includes specifically materials that can keep moisture, as shown in (Figure 4.10).

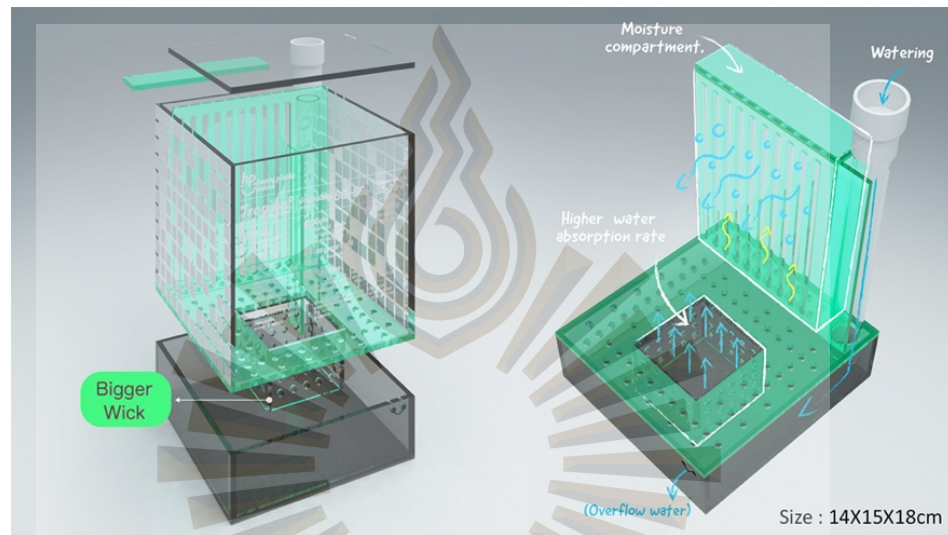


Figure 4.10 Tropical-02 model for rainforest plants

3) Desert pots are for cactus and succulent plants that do not require moisture in the soil. Some plants do not need soil moisture while some prefer watering from the bottom up. The pot's body is shallow for the ease of moisture control in the soil, (Figure 4.11). The soil mixture must be specific for cactus and succulent plants only. This pot model was designed for fast water flow to keep only a few moistures, therefore, fabric wick must be used. However, the water must be filled at the bottom when the user will not stay home for a long time.

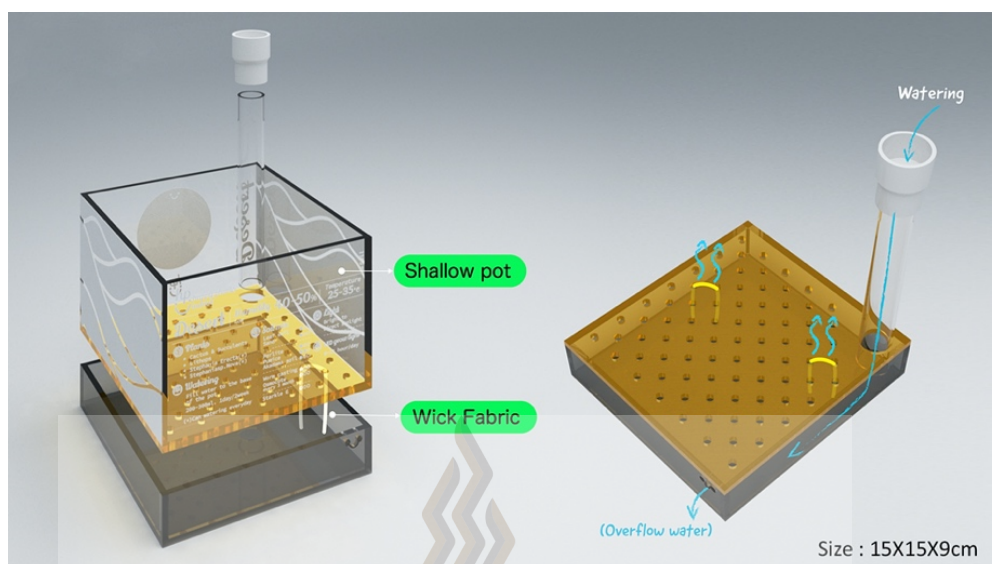


Figure 4.11 Desert pots model

4) Semi-hydro system pots for growing plants in half water and half dry are for the plants that are transferred from the soil system to the water system. This pot model was designed to solve the plants' root rot in the soil by transferring the plants from the soil to the semi-hydro system to save the plants. This pot model is easy to use and clean since no soil is needed. Clay balls and water are used, with the occasional addition of liquid fertilizer for the plants. The water must be filled not over the edge of the water tray (Figure 4.12).

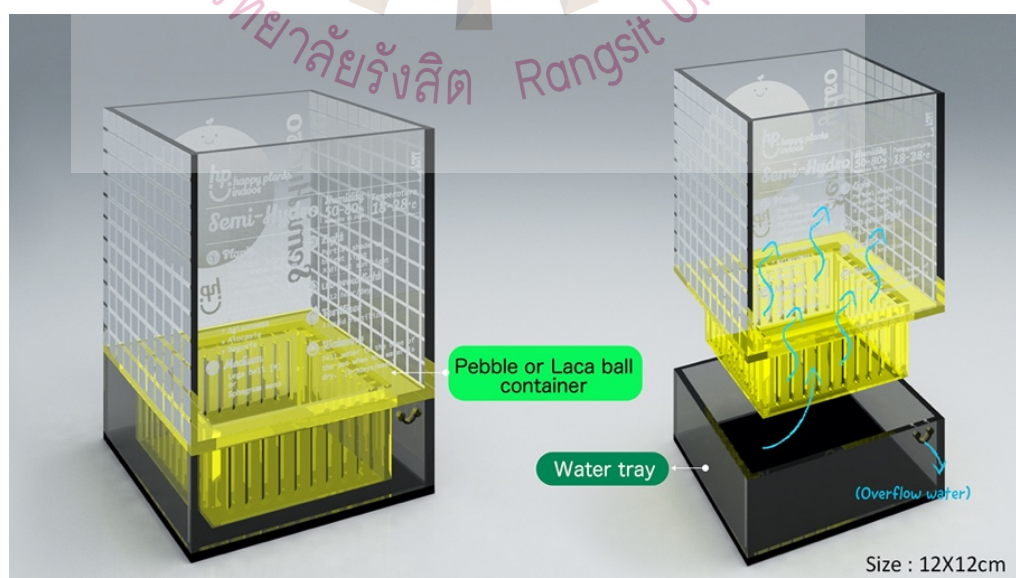


Figure 4.12 Semi-hydro model

All four types of plant pots have a different moisture retention system and water absorption to suit the needs of each plant group (Figure 4.13).

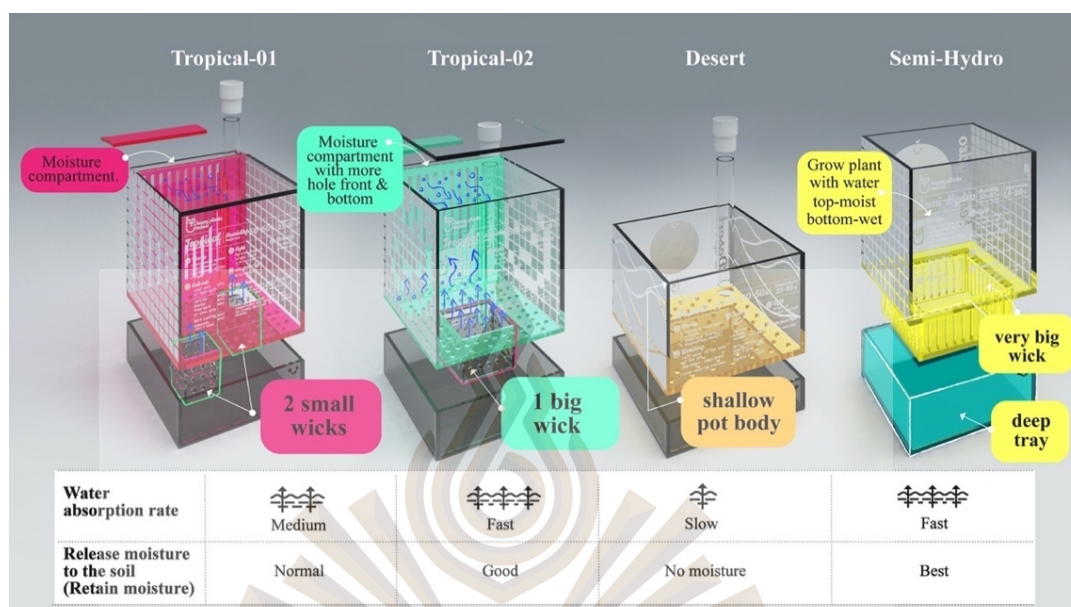


Figure 4.13 Differences of the 4 types of the plant pots

4.5 Prototypes

The plant pots generally look the same and require the growers' skills and understanding in caring for each plant. The authors have designed each pot specifically and properly for each plant to solve the common problems for amateur growers such as root rot or a lack of moisture that makes the plants dead. These designed pots do not require frequent watering, which will be very easy to care for the busy urban growers. In the prototype pot in (Figure 4.14), the authors selected transparent acrylic as a pot's material so that novice growers can observe changes in the plant's roots and soil to learn how to control watering and can observe the proper moisture of the soil. This material is also durable and can be easily cleaned.



Figure 4.14 Model of all plant pots: Pots Tropical-01, Tropical-02, Desert, and semi-hydro plant pots (from left to right) that were used to grow real plants.

The author also designed the plant pot decorations for the users who want to add graphic patterns to the transparent pots with vacuum stickers to decorate the side of the pot, (Figure 4.15). The authors selected the vacuum stickers because it is a material that can be attached to plastic without glue, making it easy to peel off and changeable. If the users want to clean the sticker, they can wash it with water or wipe it and put it back in place.

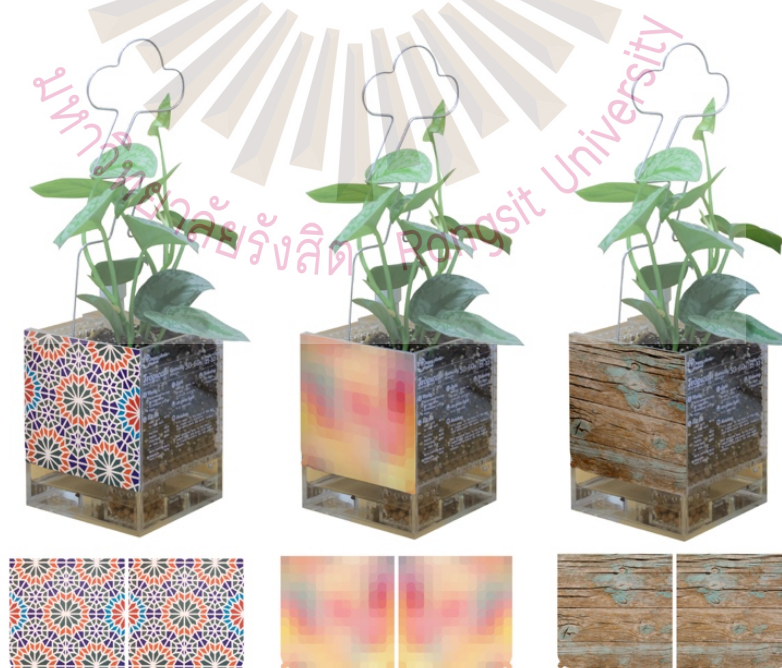


Figure 4.15 Vacuum stickers on the pot

For the convenience of the growers, if they do not want to mix the soil by themselves, the authors studied and proportioned the planting materials that suit each pot's size and type of plant in the kit. The authors prepared a set of the planting materials according to the type of the plant, such as the planting material to use with the Tropical-01 pots for the plants that prefer normal humidity levels will contain ingredients such as leaf soil, pine bark, perlite, pumice, and worm casting in a proportion of 2:1:1/2:1/2:1/2, slow-release fertilizer Osmocote, clay balls, the airy part to fill the bottom of the plant pot, fabric wick, and sphagnum moss to fill in the moisture keeper compartment. For the semi-hydro pot, the authors prepared clay balls and liquid fertilizers. The planting materials will be adjusted according to the type of the plant and the pot. However, the growers can mix the materials according to the plant care card attached to the pot and plant, which contains detailed planting materials and care information. An example of a set of soils is (Figure 4.16).



Figure 4.16 Potting materials

Each type of plant pot accommodates a different soil mixture formula according to the plant's needs. For example, some plants need high soil moisture that is not too wet, therefore, the planting material must drain well but can still retain moisture. Using peat moss or coconut coir will hold too much water, so the authors use pine bark or coco chips instead and may add vermiculite, pumice, or perlite to increase the airiness of the soil. (Figure 4.17) shows various plant materials that when mixed, have different

drainage and moisture retention properties. The authors created soil mixture formulas as suitable planting materials for use with the plants and the pots.

Soil mix formular		Fast drainage				Keep moisture		Semi Hydro	Slow drainage
Ingredients		A	B	C	D	E	F	G	H
Soil	Loam soil	●	○	○	○	●	●	Water	○
	leaf soil	○	●	●	●	●	○		●
	Peat moss	○	○	○	○	○	○		●
	Sand	○	○	○	●	○	○		○
Airy	Perlite	●	●	○	●	○	●	Lega ball popper Prebble	○
	Pumice	○	○	○	○	○	○		○
	Vermiculite	○	○	●	●	○	○		●
Moisture	Pine bark	○	○	○	○	○	○		○
	Coco coil	○	○	○	○	○	○		○
	Coco chip	○	○	○	○	○	○		○
	Coco huck	○	○	○	○	○	○		○
	Rice huck	○	○	○	○	○	○		○
	Brick	○	○	○	○	○	○		○
Nutrition &Fertilizer	Osmocote	●	○	○	○	○	○	Liquid fertilizer Hyponex Earth root HB 101	○
	Worm casting	○	○	○	○	○	○		○
	Cow Manure	○	○	○	○	○	○		○
	Leaf compost	○	○	○	○	○	○		○

Figure 4.17 A summary of the soil mixture formulas

The authors created a summary for use in the planting set, the soil mixture formulas in (Figure 4.18), and divided the selected plants into three groups: Group A (Tropical evergreen forest); normal moisture-loving plants, Group B (Tropical rainforest); high moisture-loving plants, and Group C Cacti & Succulents; plants prefer drought. To ease the care for the plants so that they can grow properly, each plant pot was designed specifically to accommodate each group of plants. (Figure 4.18) shows tables that summarized the plant pot properties describing watering quantity, moisture rate, water absorption rate, suitable plant groups for each pot model as well as proper soil mixture and pot size.

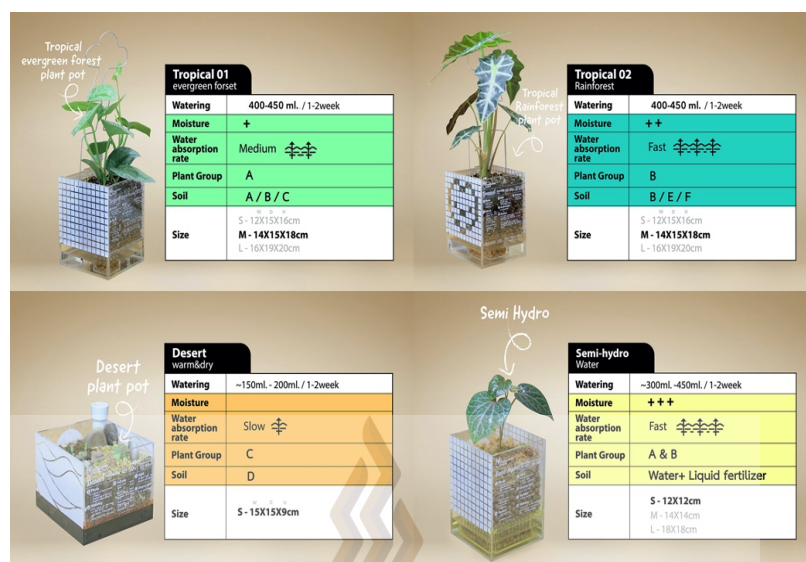


Figure 4.18 The plant pot properties description

4.6 Application design

The application was designed as an assistant and a reminder to help the users take care of the plants more easily. The steps on how to use the application are as follows:

- 1) The user must have the whole plant care system before downloading the application. Then, the user must register in the application and scan the QR code on the plant pot. The QR code will lead to the plant selection among the plant groups related to the pots.
- 2) The user can select and add the plants to the user's gallery.
- 3) The user can learn more details of the use of the pots from the instruction page and video clips that show the simple process of assembling the pots and the plants.
- 4) The user can find specific plant care details for each indoor plant by clicking the plus icon.
- 5) Notification Settings [The default setting of the reminder will be the care of the user's selected plant but the user can modify the schedule and can set a time reminder for watering and fertilizing and for replacing the soil].
- 6) Notifications

7) After clicking the plus to add the plants to the gallery, the user will find the plants' health status, which is related to the watering and care statistics of the user. The user can also edit the notifications.

8) The user can save pictures to the gallery.

9) Other service concepts are such as plant care service, plant health problems Q&A, and delivery of plant pot set.

An application's screenshot (Figure 4.19).

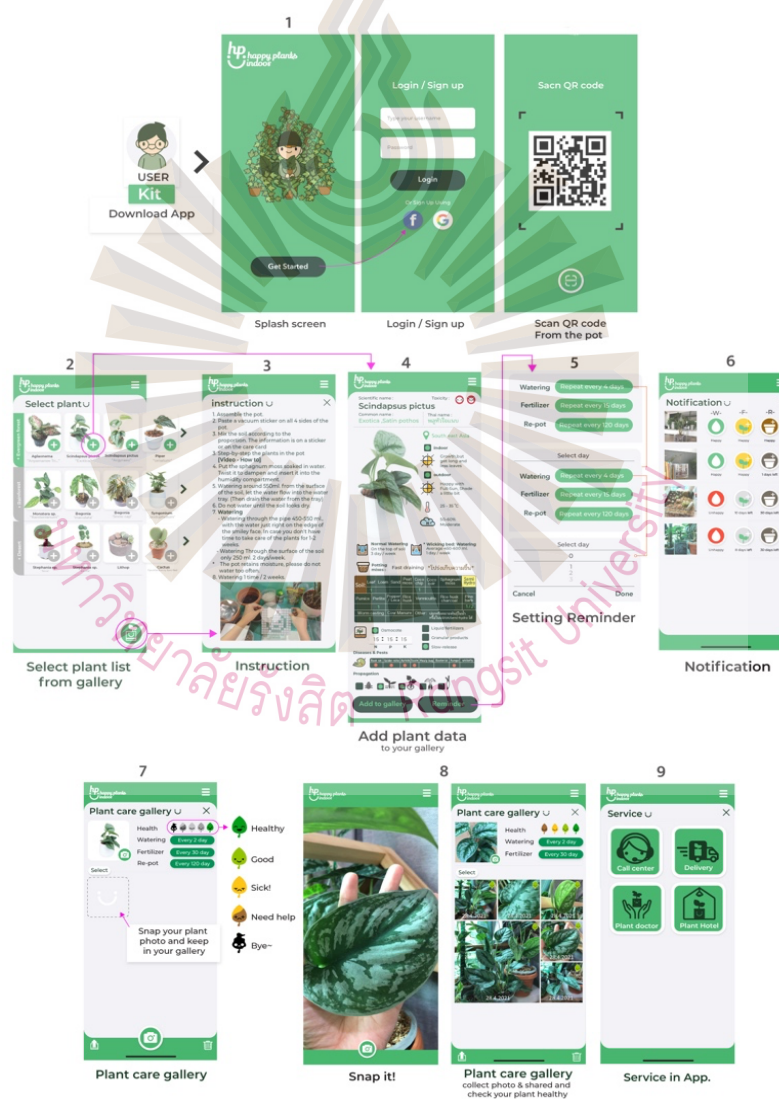


Figure 4.19 An application's screenshot

Chapter 5

Conclusion and Recommendations

5.1 Conclusion

This project aims to design a system and methods for better integrating greenery into people's lives based on the body of knowledge that is confusing and complex for amateur urban gardeners. Several issues that make the plants dead led the authors to design the plant care system specifically for the indoor plants by fabricating the plant care cards, the plant pots, and the application for taking care of each plant properly and systematically—helping the users or growers to perform more convenient cropping activities and increasing the success of indoor plants, which eventually resulted in the plants grow and thrive longer.

The plant pot design with a self-watering “Wick bed” system is suitable for controlling plant-watering and reducing root rot problems. The moisture keeper compartment inside the pot helps save the plant's life in a low humidity condition. The authors used transparent materials in the plant pot design to make it easier for the users to see the soil status and abnormalities of the plant's root system, allowing the users to understand and be able to solve problems arising from faulty plant cares for a higher survival rate.

The plant pots generally look the same and require the growers' skills and understanding in caring for each plant. The authors have designed each pot specifically and properly for each plant to solve the common problems for amateur growers such as root rot or a lack of moisture that makes the plants dead. These designed pots do not require frequent watering, which will be very easy to care for the busy urban growers.

The authors hope that this plant care system will provide the users with a natural corner in their living areas and that their plants grow well. The growers can be close to

nature, enjoy planting activities, and upgrade their skills in taking care of more complex plants.

5.2 Recommendations

As a result of the presentation of the plant care system design to the committee, there were some valuable recommendations for further development in the future as follows:

- 1) Able to choose materials from nature instead of acrylic sheets such as glass, Etc. Encouraging nature out-standing rather than displayed a container plant.
- 2) The shape of the pot can be designed to be diversified to accommodate more diverse plants.
- 3) Can be developed into larger systems such as fully integrated system tray plant pots.
- 4) Additional water pumps can be installed inside the potting system to create more oxygen to the roots. Plants will grow well.



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