DEVELOPING HEALTH-RELATED PRODUCTS TO ENHANCE QUALITY OF LIFE FOR SENIOR ADULTS AND WORKING WOMEN

BY

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ABSTRACT – PHASE 1

(Topic: Product for Supporting "Senior Adult")

With the elderly population increasing, there is a growing need for products that can aid their daily activities, such as grocery shopping. To address this issue, this study applies the product design and development method to create a grocery shopping cart that can improve the shopping experience for senior adults. Through a survey, customer feedback was collected to identify the problems and requirements of senior adults during grocery shopping. The results were then used to create a new design by combining the existing product with functional components like a smartphone holder, fan/cooler, lift-up plate, sensor, and light. Several methods, including Quality Function Deployment and Bartlett's Test, were employed to ensure the usefulness and quality of the new design. Simulated force and material analyses showed that HDPE and stainless steel were suitable for the container part (basket) and foot supporter, respectively. The outcome of this study can be used as a guideline for mass production of the designed grocery shopping cart for senior adults, which can enhance their quality of life by providing a more comfortable and convenient shopping experience. Further revisions and improvements may be made based on feedback from users.

Keywords: Design and development, Shopping Cart, Finite element analysis, Conceptual design, Usefulness of products, Quality Function Deployment, Bartlett's Test

ABSTRACT – PHASE 2

(Topic: Product for Supporting "Working Women")

Proper accomplishment of design under constraints can be facilitated with the assistance of product design and development (PDD). The development of a durable, flexible, and accessible briefcase-style bag for work-and-travel activities is presented in this study. The target customers are set as women who require specific details that lead to the comprehension of hidden issues by the designers. Key considerations for the bag's design include providing ample space and a strong body to store many items while preserving them in good condition. A solid-based baggage cover was applied to provide a shock-absorption structure. The bag's size must not exceed 40cm x 20cm x 25cm. The weight of the bag and its contents was set at 4 kg, which is the main parameter for Finite Element Analysis (FEA). To ensure safety, force distribution around the bag was simulated. When a 1000 N external force or impact force was applied to the front/back area of the bag for a relatively short period, the developed bag remained usable without any cracks found. The main body of the bag is made of polycarbonate (PC) - Acrylonitrile Butadiene Styrene or ABS plastic material, which is durable and strong. The analyzed results can serve as key guidelines for manufacturers or customers to assist work-and-travel activities with happiness. Designing a bag under constraints requires careful consideration of various design elements and materials. With the utilization of product design and development (PDD), a bag that satisfies the unique needs of the target customers can be developed, providing a durable and flexible solution for work-and-travel activities.

Keywords: Design and development, Carry-on bag, Finite element analysis, Conceptual design, Usefulness of products

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PHASE 1

PRODUCT FOR SUPPORTING “SENIOR ADULTS”

CHAPTER 1
INTRODUCTION

Presented in this chapter is the introduction of alternative design for supporting health related products (senior shopping cart), which can be categorized in six portions which are 1) Introduction, 2) Problem Statement, 3) Research Objectives, 4) Addressed Issues, and 5) Research scope and Limitations.

1.1 Introduction

Thailand's population is aging at an unprecedented rate, with the elderly population rapidly increasing. People in Thailand are living longer than ever before, leading to a rise in the country's elderly population. Currently, the third-fastest population aging rate in the world is occurring in Thailand. As a result of this demographic change, the number of people 60 and older has increased to approximately 13 million, or 20% of the total population. (Barrientos, 2019)

Additionally, estimates show that by 2050, there would be 20 million senior people in Thailand, or 35.8% of the total population. This implies that one out of every three Thais will be a senior citizen by 2050. The aging population is linked to physical decline, which is why providing adequate geriatric healthcare is Thailand's most pressing challenge. Diseases and their consequences, such as disability, weakness, and dependency, are more prevalent in the elderly population (Prince et al., 2013)

Despite the challenges that come with aging, many seniors lead fulfilling and busy lives. The image of elderly grandparents waiting patiently for family visits while rocking back and forth is progressively fading. Shopping is a routine activity that can benefit older persons physically, mentally, and socially. It can also stimulate cognitive functions. (Knickman & Snell, 2002)

Going grocery shopping is one of the most repetitive tasks we all do in our lives. While most young people can carry groceries with no problem, for senior citizens, it can be a painful burden. Hence, health-related products like walking aids, shopping

carts, and other assistive devices can provide necessary support for a better shopping experience for senior adults (Bright & Coventry, 2013)

In addition to their physical advantages, shopping trips can boost social interaction by helping seniors to interact with new people and host gatherings for their friends and family. These basic daily practices can have a significant impact on the quality of life of seniors. Therefore, it is essential to promote and facilitate such activities and provide adequate support to help the elderly population maintain their physical and mental health.

1.2 Problem Statement

To address the challenges faced by seniors during grocery shopping, various innovative solutions have been proposed. For instance, some supermarkets have started offering home delivery services and online shopping options to cater to the needs of seniors. In addition, several grocery stores have also introduced motorized shopping carts and other assistive devices that help seniors move around the store with ease.

Moreover, some grocery stores have initiated partnerships with healthcare providers to offer on-site medical screenings and health education services to seniors. Such partnerships aim to promote healthy aging and enable seniors to stay informed about their health status. These initiatives not only provide seniors with a more enjoyable and convenient shopping experience but also help to improve their overall quality of life.

Another way to enhance the shopping experience for seniors is by creating a more social and community-oriented environment in grocery stores. This can be achieved by organizing social events, classes, or workshops that cater specifically to seniors. Such events provide opportunities for seniors to socialize with others and build new relationships. Furthermore, incorporating geriatric healthcare services within the grocery store concept can be a valuable approach. Providing access to healthcare services such as routine check-ups, medication management, and mental health counseling can help seniors maintain their health and well-being.

Based on the observed situation and the customers' viewpoints, the most important factor to consider is that providing physical and social advantages with a

multipurpose concept is critical to enhancing the shopping experience of seniors. Innovative solutions that cater to the needs of seniors and promote healthy aging can contribute significantly to improving the senior population's standard of population in Thailand.

1.3 Objective

The main objective of this research is to create a health-related product design for a shopping cart that supports seniors' needs while shopping. The design should be ergonomic, multifunctional, universal, and safe.

1.4 Addressed Issues

To achieve the research objective of enhancing the shopping experience for seniors, several factors need to be considered. Firstly, customer demand should be analyzed to identify the specific needs and preferences of seniors. This can be achieved through surveys, interviews, and focus groups to gather information on the challenges faced by seniors during shopping and their desired solutions.

Secondly, data acquisition and interpretation are crucial to understand the shopping behavior of seniors. This involves collecting and analyzing data on their physical abilities, cognitive function, and social engagement during shopping. The data can be collected using various methods, including wearable devices, sensors, and observations.

Thirdly, the designing process should consider the physical and social advantages of the shopping experience for seniors. The design should aim to improve accessibility, reduce physical strain, and enhance social interaction. This can be achieved through the incorporation of features such as wider aisles, ergonomic handles on shopping carts, and social areas for resting and socializing.

Finally, the manufacturing process should ensure that the products and services meet the design specifications and are of high quality. The manufacturing process should also take into account the production cost and scalability of the product or service to ensure that it is commercially viable.

Key consideration: a multi-disciplinary approach involving customer demand analysis, data acquisition and interpretation, designing process, and manufacturing process is required to achieve the research objective of enhancing the shopping experience for seniors.

1.4.1 Customer Demand

Customer demand is a crucial factor that affects the design and function of the product. Understanding customer demand is essential in developing a product that meets their needs and expectations.

- *Sound of Customer:* to design a product that meets customer demand, it is necessary to listen to their feedback and opinions.
- *Target Customer:* Identifying the target customer is crucial to designing a product that meets their specific needs and expectations.

1.4.2 Data Acquisition and Interpretation

Data acquisition and interpretation are crucial steps in designing a product that meets customer demand.

- *How to Collect the Data from Customer?*

Choosing an appropriate data collection method is essential to obtain accurate data that will help developers decide on the design and identify customer needs.

- *Which Method to Interpret the Received Data?*

After collecting data, it is necessary to interpret the data accurately to identify important points that will meet customer demand and help convince them to purchase the product.

1.4.3 Designing Process

The designing process is essential in developing a product that meets customer demand. It involves creativity, planning, calculation, tools, and precision. Besides, some additional suggestions for elaborating on the designing process:

- *Creativity:* The designing process requires creativity to come up with a unique and innovative product that meets the customer's needs. This involves brainstorming, ideation, and conceptualization, which are essential in creating a product that stands out in the market.
- *Planning:* The designing process also involves planning, which is necessary for defining the product's scope, setting timelines, and identifying resources required. This phase ensures that the product design is aligned with the project goals and objectives.
- *Calculation:* Designers need to perform calculations to determine the product's technical specifications and ensure that it functions as intended. This may involve analyzing data, performing simulations, and making design decisions based on the results.
- *Tools:* Designers use a range of tools to create a product prototype, such as computer-aided design (CAD) software, 3D printers, and modeling tools. These tools help designers visualize the product, identify design flaws, and refine the product design.
- *Precision:* The designing process requires precision to ensure that the product is functional, safe, and reliable. This includes following industry standards and regulations, performing quality checks and testing, and ensuring that the product meets customer expectations.

Key consideration: the designing process is an essential phase in product development that requires creativity, planning, calculation, tools, and precision to create a product that meets customer demand.

1.4.4 Manufacturing Process

The manufacturing process is essential in determining which methods to use to manufacture the newly designed product. The process must consider materials, mechanisms, and dimensions of the product. Moreover, some additional details on the manufacturing process:

- *Materials:* The choice of materials used in the manufacturing process can affect the quality and durability of the product. Manufacturers must consider the properties of different materials such as strength, weight, and cost, and choose materials that will best suit the product's purpose.
- *Mechanisms:* The mechanisms involved in the product must also be considered during the manufacturing process. This includes the product's assembly, disassembly, and maintenance. Manufacturers must ensure that the product can be easily assembled and maintained by the end-user.
- *Dimensions:* The dimensions of the product must be carefully considered during the manufacturing process. The product must be designed to fit within certain size limitations and specifications, and manufacturers must ensure that the product's dimensions are accurate to avoid any issues during the production process.
- *Quality control:* The most important phase in the manufacturing process is quality control. Manufacturers must have a system in place to ensure that each product meets the necessary quality standards before it is shipped to the customer. This includes testing the product for functionality, durability, and safety.
- *Cost-effectiveness:* The manufacturing process must also consider the cost-effectiveness of producing the product. Manufacturers must find a balance between producing a high-quality product and keeping the production costs low to ensure that the product is affordable for customers.

Key consideration: the manufacturing process involves a wide range of factors that must be carefully considered to ensure that the final product meets customer demand and quality standards while being cost-effective to produce.

1.5 Research Scope and Limitations

The limitations of this research include time constraints, budget limitations, and the availability of resources. The research will be limited to a specific geographic

location and may not consider cultural and social factors that may affect the seniors' preferences and needs. Additionally, the study will not consider the manufacturing process's environmental impact and sustainability measures, which may affect the product's overall cost-effectiveness. Finally, the research will not address the appliance's maintenance and repair requirements, which may affect its longevity and functionality.

CHAPTER 2
RESEARCH BACKGROUND

This chapter presents the reviews of related research about the existing product of senior shopping cart. Some related works and customer experience have discussed to translate into product design.

2.1 Target Customer

Grocery shopping is an activity that cannot be avoided in anyone's everyday life. Although grocery shopping can be enjoyable in general, certain customers, particularly seniors with limited strength and abilities, find it to be bothersome and challenging. (Villegas & Saito, 2017) The research aims to generate a health-related product design for shopping cart that can support the needs of seniors and is more attractive based on human-centered design and universal design principles, given the rapidly growing aging population and the difficulty for seniors when grocery shopping.

Since the human-centered design approach places actual people at the center of the development process, it enables the development of products and services that resonate and are suited to the demands of the target market. The concept is divided into three parts: inspiration, ideation, and implementation. (Cooley, 2000)

Figure 2.1 Human-Centered Design Concept

1) Inspiration: Learning from customers comes first in the process. Empathy, or the capacity to understand another person's experiences and feelings, is necessary for the inspiration phase. By asking questions from the perspective of your users, you may learn what products they currently use, why and how they use them, and the problems they're attempting to solve.

2) *Ideation:* The goal of this step is to generate as many ideas as possible depending on the results of the data collection. The goal of this procedure is to eliminate concepts that are not practical or viable, develop a prototype, and solicit input from potential users.
3) *Implementation:* Putting that excellent solution on the market is the last step in the process. Where users are and how they desire to be marketed should be taken into account first.

To identify target customer, target customer is the person likely to purchase product. The components might include a specific age, a specific gender, and the reasons these customers are most likely to purchase your products. To create the proposed design, some related works have been discussed.

2.2 Customer Requirement

Customer requirements are the specific expectations of product features that are designed to fulfill. The first method is to gather raw data from customers to contact with customers and experience with the use environment of the product. There are two sub-methods which are doing survey questions and observing the product in use. For the doing survey question, the related questions were launched to a single target customer and discuss feedback from answers. When customers use an existing product for which a new product is intended, it is necessary to observe the product in use to acquire information. This can disclose crucial information about customer wants. (Childerhouse & Towill 2000)

After obtaining the results from the questionnaire (100 respondents), the data was analyzed to find the customer viewpoint and translate into design that follows customer needs (senior adults). The data from questionnaire is shown below. Table 2.1 shows the general information about gender, age, occupation, status, members in household and monthly salary. Table 2.2 shows problems occurred in real life, daily activities, and obstacles of senior adults. Table 2.3 shows the data about the product such as useful existing product and color.

Table 2.1 Descriptive Analysis of Respondents (General Information)

Gender	**Number of Respondents**	**Percentage**
Female	58	58
Male	42	42
Age	**Number of Respondents**	**Percentage**
51-60	44	44
61-70	52	52
71-80	3	3
>80	1	1
Occupation	**Number of Respondents**	**Percentage**
Government Official	31	31
Government Employee	1	1
Retired Government	39	39
Official	4	4
Company Employee	1	1
State Enterprise Employee	15	15
Self-Employed	6	6
Hose Maker	1	1
Employee	1	1
Agriculturist	1	1
Unemployed		
Status	**Number of Respondents**	**Percentage**
Single	10	10
Married	78	78
Divorced/Widowed	10	10
Separated	2	2
N/A	0	0

Members in Household	Number of Respondents	Percentage
1	7	7
2	17	17
3	30	30
4	29	29
5	12	12
>5	5	5

Monthly Salary	Number of Respondents	Percentage
0 – 15,000 Baht	9	9
15,001 – 25,000 Baht	14	14
25,001 – 35,000 Baht	17	17
35,001 – 50,000 Baht	27	27
50,001 – 100,000 Baht	26	26
> 100,000 Baht	7	7

Table 2.2 Descriptive Analysis of Respondents (Problems and Activities)

Four Favorite Leisure Activities	Number of Respondents	Percentage
Cooking	43	10
Traditional Shopping	67	16.75
Online Shopping	23	5.75
Housecleaning	40	10
Travelling	63	15.75
Outdoor Exercise	46	11.5
Indoor Exercise	15	3.75
Religious Activities	16	4
Language Learning	2	0.5
Communication with Family and Friends	59	14.75
Art Activities	0	0
Musical Activities	1	0.25
Embroidery	6	1.5
Singing	13	3.25
Gardening/Planting	4	1
Watching TV/Movies	1	0.25
Working	1	0.25

Three Serious Health Problems	Number of Respondents	Percentage
Eyes and Vision	52	17.3
Movement	75	25
Hearing	22	7.3
Respiration	8	2.7
Mental	11	3.7
Digestive System	37	12.3
Excretory System	19	6.3
Nervous System	29	9.7
Circulatory System	26	8.7
Reproductive System	1	0.3
Hormones	8	2.7
Taste	5	1.7
Pains and Aches	2	0.7
Allergy	2	0.7
Amnesia	2	0.7
None	1	0.3

Three Obstacles for Living	Number of Respondents	Percentage
Technology	54	18
Fine Motor Skills	19	6.3
Gross Motor Skills	36	12
Small Button Pressing	42	14
Uncomfortable Product	61	20.3
Environment and Safety	39	13
Recognition	46	15.3
Pains and Aches	1	0.3
None	1	0.3

Table 2.3 Descriptive Analysis of Respondents (Product)

Two Useful Products	**Number of Respondents**	**Percentage**
Wheelchair	56	28
Walker	27	13.5
Clutches	29	14.5
Cane	63	31.5
Walking stick	13	6.5
None	12	6
Two Interesting Products	**Number of Respondents**	**Percentage**
Multifunctional Folding Shopping Cart	36	18
Portable Lift-up Seat	33	16.5
Fall Detector	27	13.5
Exercise Equipment for Seniors	50	25
Smart Tracker	31	15.5
Reminder Gadget	20	10
None	3	1.5
Color	**Number of Respondents**	**Percentage**
Classic	38	38
Colorful	11	11
Romantic	14	14
Beige tone	37	37

2.3 Market Survey on the Related Products

It is important to consider the specific needs and challenges that seniors face when developing products for them, such as mobility issues, decreased strength and balance, and cognitive decline. The multifunctional folding shopping cart can provide support and convenience for seniors while shopping, while the portable lift-up seat can help them take a break and rest when needed. The fall detector can help alert others in case of an accident, and exercise equipment designed for seniors can help them maintain strength and balance. The smart tracker can help keep track of important items and provide location information if they become lost, and the reminder gadget can help seniors remember important tasks and appointments (Tedesco, Barton, and O'Flynn, 2017) By addressing these needs and challenges, manufacturers can create products that improve the quality of life for seniors and meet the growing demand for senior-friendly products.

2.3.1 Various Types of Related Products

Recently, there has been an increase in the availability of products in the senior market, as shown in Figure 1. These products were identified through surveys, research, and analyzing the needs of seniors when grocery shopping. The table (Table 2.4) provides a comparison of six related products, including their description, pros, and cons, in order to determine the most suitable functions and designs for senior adults to use while grocery shopping.

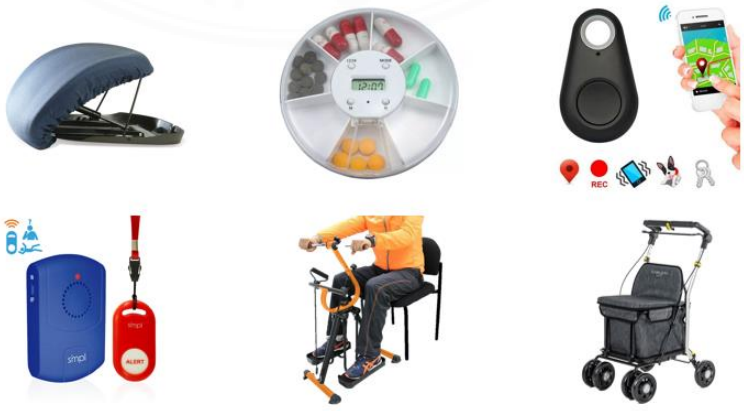


Figure 2.2 Various Types of Related Products

Table 2.4 Various Types of Related Products

Type	Description	Pros	Cons
Folding Shopping Cart 	This tool is used to move things about while traveling, in the city, or at a workplace. This is the best way to easily transport a large range of goods. When not in use, it collapses into a smaller space than conventional trolleys for convenient storage anyplace.	- Foldable - Easy-to-use - Versatility in usage - Multifunctional	- Some shopping carts have a small storage space. - Some shopping carts don't provide ergonomic design.
Portable Lift-Up Seat 	The product provides up to 70% lift assist for users who otherwise would need help getting up from a seated position.	- Portable - Easy-to-use - Safely standing	- Limitation of body weight up to 350 lbs.
Fall Detector 	Devices that detect falls automatically use technology to identify seniors who are at risk of falling and quickly summon assistance. (Wigand, 2023)	-Professionally monitored - Wearable	- False alarm - Expensive

Type	Description	Pros	Cons
Exercise Equipment for Seniors 	Any equipment or tool used during physical activity to improve the experience or results of a workout regimen by adding fixed or adjustable quantities of resistance or to otherwise improve the strength or conditioning effects of that exercise. (Vishwanathan, 2023)	- Several exercises in one equipment - Multiple settings and adjustments - Foldable	- Difficult to assembly - Seat may become wobbly after a few uses. - The equipment may be noisy.
Smart Tracker 	The tool or application for keeping an eye on and following users' movements and locations. It may be used to monitor fitness-related data including heart rate, calories consumed, and walking or running distance.	-Track location - Accountability - Set goals - Stay connected (Sankaranarayanan, Veeraraghavan, and Chellappa, 2008)	-Not entirely accurate - Limited battery life - Expensive

Type	Description	Pros	Cons
Reminder Gadget 	Reminder is the most common type of alarm gadgets that can be used in and of different ages. They can be used to receive and make the calls easier a person can get on the phone and for notifications when the issue is not detected.	-Remind Something -Send notification	- Limited battery life

2.3.2 The Suitable Product for the New Design

After analyzing the pros and cons of various products for senior adults based on customer requirements and research, the folding shopping cart is deemed the most suitable product. Its main function is to transport items with compact size storage when grocery shopping, and it also provides a seat for personal use. In this case, the seat is designed to lift-up to help senior adults reduce force when standing up. Additionally, the product should incorporate a smart tracker to track the location of the shopping cart and detect where senior adults are. Therefore, the final product design should combine three concepts: the folding shopping cart, portable lift-up seat, and smart tracker.

2.3.3 Existing Product from Online Market

The folding shopping cart is the main component of the health-related product being researched. To analyze this component, existing products from online marketplaces such as Amazon, Lazada, and Alibaba are being evaluated based on parameters such as size, price, load capacity, weight, storage space, foldable function, brake system, and seating plate. While most existing products have a universal design for people of all ages, different life stages have different criteria for evaluation. Table 2.5 displays existing products from Amazon, Table 2.6 displays products from Lazada, and Table 2.7 displays products from Alibaba.

2.3.4 Existing Product from Amazon

Table 2.5 Existing Product from Amazon

No.	Product	Details	Functional Component			
			Basket	Foldable Design	Wheel Brake	Seat Plate
1		**Drive Medical 10257RD-1** **Size:** 12”x 12” x 21” **Price:** 1,860 Baht **Load Capacity:** 136 Kg **Weight:** -	✓		✓	✓
2		**Vive Mobility 3 Wheel Rollator Walker** **Size:** 21”x 26” x 31-38.5” **Price:** 4,145 Baht **Load Capacity:** 113 Kg **Weight:** -	✓	✓	✓	
3		**BEYOUR Upright Walker** **Size:** 25”x 28” x 45-51” **Price:** 6,700 Baht **Load Capacity:** 136 Kg **Weight:** 10 Kg	✓	✓	✓	✓
4		**KMINA PRO- Rollator Walker** **Size:** 21.2”x 16” x 32.8-37.2” **Price:** 4,780 Baht **Load Capacity:** 100 Kg **Weight:** 5.5 Kg	✓	✓	✓	

For the *first product* from Amazon, "Drive Medical 10257RD-1", it has a dimension of 12 x 12 x 21 inches and a load capacity of 136 kg. The product is made of alloy steel and features a durable padded seat and backrest that can be folded up or down. The sturdy steel frame includes a basket or pouch for storing personal items. The price of this product is 1,860 Baht.

The *second product* from Amazon is the "Vive Mobility 3 Wheel Rollator Walker", with a dimension of 21 x 26 x 31-38.5 inches and a load capacity of 113 kg. The product is made of aluminum and provides stable assistance for seniors and those who need light to moderate support. Its design is ideal for navigating busy areas, narrow hallways and doorways, and it can be folded for storage and transport. Dual brakes and an adjustable handlebar on the strong aluminum frame add to the stability when navigating incline-based terrain and providing secure parking. The price of this product is 4,145 Baht.

The *third product* from Amazon is the "BEYOUR Upright Walker", with a dimension of 25 x 28 x 45-51 inches and a load capacity of 136 kg. The product is made of aluminum and features large wheels, an adjustable holding angle, a large storage bag, and a reinforced frame. The price of this product is 6,700 Baht.

The *last product* from Amazon is the "KMINA PRO-Rollator Walker", with a dimension of 21.2 x 16 x 32.8-37.2 inches and a load capacity of 100 kg. The product is made of aluminum and is designed for people with medium to low dependency who need help when walking and do not want to lose their autonomy. The price of this product is 4,780 Baht.

2.3.5 Existing Product from Lazada

Table 2.6 Existing Product from Lazada

No.	Product	Details	Functional Component			
			Basket	Foldable Design	Wheel Brake	Seat Plate
1		**Ai Lijiao Elderly Shopping Trolley** **Size:** 18”x 19.5” x 35.8” **Price:** 5,724 Baht **Load Capacity:** 100 Kg **Weight:** 4.5 Kg **shorturl.at/pEFMV**	✓		✓	✓
2		**Elderly Stairs Shopping Cart** **Size:** 11.8”x 9” x 38” **Price:** 4,518 Baht **Load Capacity:** 200 Kg **Weight:** 2.5 Kg **shorturl.at/nrtwI**	✓	✓		
3		**Portable Large Shopping Cart** **Size:** 17.7”x 22.4” x 36” **Price:** 3,162 Baht **Load Capacity:** 150 Kg **Weight:** - **shorturl.at/uJL57**	✓	✓		✓
4		**Cordial Shining Elderly Shopping Cart** **Size:** 16”x 18.5” x 33.8-35.4” **Price:** 12,172 Baht **Load Capacity:** - **Weight:** 8 Kg **shorturl.at/lABEW**	✓	✓	✓	✓

The *first product* from Lazada, the “Ai Lijiao Elderly Shopping Trolley”, has a load capacity of 100 kg and is made of steel. Its dimensions are 18 x 19.5 x 35.8 inches, and it is designed to be used both for walking and for carrying out daily shopping tasks. The trolley features a padded and resistant seat for resting during the walk, and it is priced at 5,724 Baht.

The *second product* from Lazada, the “Elderly Stairs Shopping Cart”, has a load capacity of 200 kg and is made of steel. Its dimensions are 11.8 x 9 x 38 inches, and it is designed to be waterproof, foldable, and capable of climbing stairs. It also provides a large capacity for carrying shopping items and is priced at 4,518 Baht.

The *third product* from Lazada, the “Portable Large Shopping Cart”, has a load capacity of 150 kg and is a stroller that includes features such as a built-in seat for laundry, supermarket, shopping, and a folding chair. Its dimensions are 17.7 x 22.4 x 36 inches, and it is priced at 3,162 Baht.

The *last product* from Lazada, the “Cordial Shining Elderly Shopping Cart”, has a dimension of 16 x 18.5 x 33.8-35.4 inches. It features a handbrake with rear-wheel locks, height adjustable grip, removable bag, and ergonomic side support. It is priced at 12,172 Baht.

2.3.6 Existing Product from Alibaba

Table 2.7 Existing Product from Alibaba

No.	Product	Details	Functional Component			
			Basket	**Foldable Design**	**Wheel Brake**	**Seat Plate**
1		**Sedo 23hopping Trolley Cart Unfolding** **Size:** 25.6”x 35” x 43” **Price:** 2,876 Baht **Load Capacity:** 40 L **Weight:** - **shorturl.at/vxGH0**	✓			✓
2		**Walker Rollator with Shopping Cart** **Size:** - **Price:** 820 Baht (>=300 pieces) **Load Capacity:** 150 Kg **Weight:** 7.7 Kg **shorturl.at/qwAD0**	✓		✓	
3		**Foldable Reusable Shopping Cart Bag** **Size:** 23.6”x 26.8” x 35.8” **Price:** 685 Baht **Load Capacity:** 35 Kg **Weight:** 3.4 Kg **shorturl.at/hjmoA**	✓	✓		
4		**Health Smart Rollator Walker** **Size:** 25.6”x 32.7” x 31.5-36.6” **Price:** 1,757 Baht **Load Capacity:** 130 Kg **Weight:** 8 Kg **shorturl.at/kDO05**	✓	✓	✓	✓

The *first product* from Alibaba is the “Sedo Hopping Trolley Cart Unfolding”, which has dimensions of 25.6 x 35 x 43 inches and a volume of 40 liters. This product is made with a wooden seat and metal rack and is commonly used in supermarkets and stores. It is an unfolding product and is priced at 2,876 Baht.

The *second product* from Alibaba is the “Walker Rollator with Shopping Cart”, which has a load capacity of 150 Kg. This product has anatomically shaped handles that are adjustable for greater comfort, and brakes for absolute speed control with wheels that can be locked. The price of this product is 820 Baht.

The *third produc*t from Alibaba is the “Foldable Reusable Shopping Cart Bag”, which has dimensions of 25.6 x 32.7 x 31.5-36.6 inches and a load capacity of 130 Kg. This product is priced at 685 Baht.

The *last product* from Alibaba is the “Health Smart Rollator Walker”, which has dimensions of 23.6 x 26.8 x 35.8 inches and a load capacity of 130 Kg. This product is made with titanium and provides functions for increasing mobility, height adjusting, and a seat plate with a backrest. It is priced at 1,757 Baht.

2.3.7 Market Survey on the Related Products

Table 2.8 Comparison between Product from Market Survey

Product	Functional Components	Product	Functional Components
	Basket: Yes Foldable: No Wheel Brake: Yes Seat Plate: Yes		Basket: Yes Foldable: Yes Wheel Brake: No Seat Plate: Yes
	Basket: Yes Foldable: Yes Wheel Brake: Yes Seat Plate: No		Basket: Yes Foldable: Yes Wheel Brake: Yes Seat Plate: Yes
	Basket: Yes Foldable: Yes Wheel Brake: Yes Seat Plate: Yes		Basket: Yes Foldable: No Wheel Brake: Seat Plate: Yes
	Basket: Yes Foldable: Yes Wheel Brake: Yes Seat Plate: Yes		Basket: Yes Foldable: No Wheel Brake: Yes Seat Plate: No
	Basket: Yes Foldable: No Wheel Brake: Yes Seat Plate: Yes		Basket: Yes Foldable: Yes Wheel Brake: Seat Plate: No
	Basket: Yes Foldable: Yes Wheel Brake: No Seat Plate: No		Basket: Yes Foldable: Yes Wheel Brake: Yes Seat Plate: Yes

After examining all the models, it is evident that Amazon offers a diverse range of styles at varying prices when compared to the other marketplaces.

- The products from Lazada, on the other hand, exhibit similar styles and price points.
- In contrast, the products from Alibaba feature a unique style that sets them apart from the others.
- To compare the functional components of the products, factors such as storage space (basket), foldable function, brake system, and seat plate were taken into consideration to create a new model.

Upon analyzing the data presented in **Table 2.8**, it can be concluded that the ***"Health Smart Rollator Walker"*** from ***Alibaba's online market*** is the best model based on its features and overall value.

2.4 Product Design and Development (PDD)

Product design and development (PDD) encompasses a complete cycle of steps, starting from the conceptualization to the product deployment, which includes five main stages: concept development (CD), system-level design, detail design, testing and refinement, and production ramp-up. The ultimate goal of the product development process is to design and develop products that meet customer requirements. (Banker, Bardhan, and Asdemir, 2006; Cross, 2021; Homburg, Schwemmle, and Kuehnl, 2015; Ulrich, Eppinger, and Yang, 2008)

The product design and development process involves transforming a set of inputs into a set of outputs. In the current research, the process culminates in the testing and refinement phase. The concept development phase involves planning how to create the prototype by collecting useful information such as existing product, customer demand, calculation concept, and effective methods. After gathering all relevant data, the design was created and converted into a diagram called the "system-level design" and the final design with relevant information called the "detailed design." The product was then tested by the target customers (senior adults), and their feedback was analyzed to revise and refine the design.

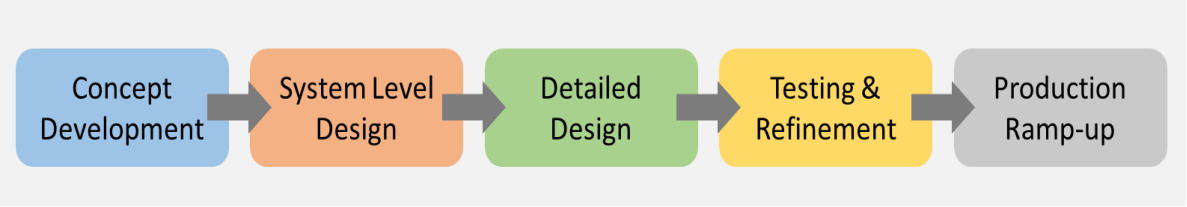


Figure 2.3 Product Design and Development

2.5 Quality Function Deployment (QFD) and The House of Quality (HoQ)

Quality function deployment (QFD) is a powerful tool that enables companies to translate customer needs and wants into product features that can satisfy those needs. To make sure that customer requirements are included into the finished product, QFD is used early in the design phase. Based on technological capabilities, it is also used as a planning tool to determine the most crucial areas to concentrate on. QFD charts enable the team to set targets for the most important customer issues and identify the technical solutions to achieve them (Bossert, 2021; Bouchereau & Rowlands, 2000; Chan & Wu 2002; Rianmora & Werawatganon, 2021)

The House of Quality (HOQ) is an important part of QFD and is a product planning matrix that demonstrates the connections between client demands and the strategies and tactics businesses might employ to meet those demands. HOQ is a key instrument for encouraging collective decision-making during the implementation of quality functions (Chan & Wu, 2002; Hauser & Clausing, 1988; Klochkov, Klochkova, Volgina, and Dementiev, 2016; Park & Kim, 1998)

In this research, the House of Quality concept is used to identify engineering specifications that align with customer requirements. The HOQ is divided into six steps. The first step is to identify customer requirements, followed by analyzing competitors in the second step. The third step involves identifying engineering specifications, while the fourth step assigns a score of 0 (none), 1 (weak), 3 (moderate), or 9 (strong) to the relationship between customer requirements and engineering attributes. The fifth step is to calculate the technical importance score, and the final step is to identify correlations between engineering specifications.

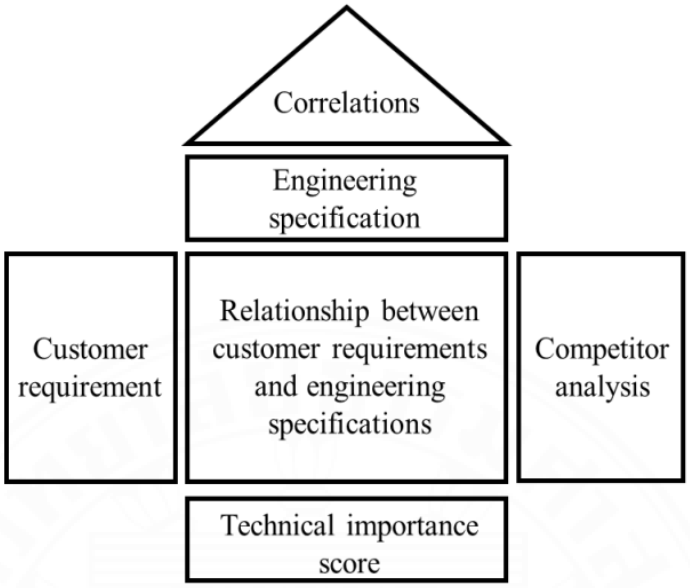


Figure 2.4 House of Quality

2.6 Bartlett's Test

Bartlett's test is a statistical test that is commonly used to determine whether multiple samples are from populations with equal variances, which is also known as homoscedasticity. This test is used to verify the assumption of equal variances across groups or samples, which is required for some statistical tests such as analysis of variance (ANOVA).

Bartlett's test is an inferential procedure that compares the variances of different populations to determine whether they are statistically significant. The null hypothesis of this test is that the population variances are equal. Bartlett's test assumes that the data being analyzed is normally distributed. By using Bartlett's test, researchers can determine whether the variances of the population are equal, and whether it is appropriate to use certain statistical methods that require the assumption of equal variances (Arsham & Lovric, 2011; Bartlett, 1950; Viwatwongkasem, Vorapongsathorn, & Taejaroenkul, 2004)

2.7 Expected Design

After evaluating several existing products, the "Health Smart Rollator Walker" was selected as the reference model for this research. This model was chosen because it has multiple functional components that can support various senior adult activities, and its design can be easily improved for additional functions. The new design is expected to have dimensions of approximately 24 x 27 x 36 inches, and it will incorporate concepts of innovation, easy accessibility, simplicity, and universal design. Additional functions can be added based on customer requirements and engineering methods.

The expected design will combine the existing product with new functional parts, including a smartphone holder, fan/cooler, lift-up plate, sensor, and light. These additional features will enhance the usability and convenience of the product for senior adults.

Figure 2.5 Expected Design

CHAPTER 3
RESEARCH CONCEPT

After collecting data from questionnaires and analyzing existing products in the online market, five main activities were established to construct the new design of a multifunctional shopping cart:

1. *Product design and development (PDD):* In this phase, the design team worked on conceptualizing and developing the new shopping cart design based on the data collected from the questionnaire and analysis of existing products. The design team also considered the ergonomic, multifunctional, universal, and safe aspects of the new shopping cart.

2. *Sample size analysis:* A sample size analysis was conducted to determine the appropriate sample size needed for the research. This analysis helped to ensure that the sample size was large enough to generate accurate results.

3. *Data collection and analysis (questionnaire):* A questionnaire was designed and administered to seniors to collect data on their shopping habits, preferences, and challenges. The data collected was analyzed to identify the key requirements and features needed in the new shopping cart.

4. Quality function deployment (QFD): QFD was used to translate customer requirements into technical requirements. This technique helped to ensure that the design team focused on meeting the needs and preferences of seniors during the design and development process.

5. Bartlett's test: Bartlett's test was used to assess the homogeneity of the data collected from the questionnaire. This test helped to ensure that the data collected was reliable and could be used to make informed design decisions.

These five activities were essential in the development of a new multifunctional shopping cart that meets the needs of seniors.

3.1 Product Design and Development (PDD)

To ensure the successful development of the new multifunctional shopping cart, the concept will be divided into five main parts using the Product Design and Development (PDD) process (Fig.3.1).

The *first part* is conceptual design, where the research team will brainstorm and generate ideas for the shopping cart's design and features based on the research findings and customer feedback.

The *second part* is system-level design, where the team will evaluate the feasibility of the conceptual design and develop a preliminary design for the shopping cart. This stage will also include analyzing the system's functional requirements and identifying potential technical challenges.

The *third part* is detailed design, where the team will create a detailed design of the shopping cart, including the selection of materials, dimensions, and mechanisms. This stage will also involve conducting a prototype testing to ensure that the shopping cart meets the needs of senior citizens.

The *fourth part* is testing and refinement, where the team will evaluate the performance of the shopping cart in terms of its usability, durability, and safety. This stage will also involve identifying and addressing any design flaws and making necessary changes to improve the shopping cart's functionality.

The *final part* is product ramp-up, where the team will prepare for the manufacturing and launch of the shopping cart. This stage will include creating production plans, ensuring quality control, and setting up a distribution strategy (Keutzer, Newton, Rabaey, and Sangiovanni-Vincentelli, 2000; Otto, 2003; Terwiesch & Bohn, 2001)

For this research, the process is started with concept development and ended up with testing and refinement.

Figure 3.1 Product Design and Development

Key point: it is important to note that each phase of the product design and development process is iterative and may require revisiting previous phases to ensure the final product meets the desired specifications. Testing and refinement is especially important as it allows for any necessary modifications to be made before the product is launched. Additionally, obtaining feedback from real users during the testing and refinement phase can be beneficial in further improving the product design.

3.2 Sample Size Analysis

The formula for determining the minimum sample size needed to estimate the true proportion is based on several factors, including the desired level of precision, the margin of error, and the confidence level. These factors must be considered when determining the appropriate sample size for a health-related survey. A larger sample size generally provides more accurate estimates of health-related issues, but also requires more time and resources to collect and analyze the data.

In this research, the sample size was determined based on the target population of seniors who shop for groceries. A survey was conducted to collect data on their shopping habits, preferences, and needs. The sample size was calculated using the formula mentioned above to ensure that the results would be statistically significant and representative of the target population.

It is important to note that while a larger sample size generally provides more accurate results, it is also important to consider other factors such as the diversity of the sample and the sampling method used to ensure that the results are not biased.

Additionally, the sample size should be large enough to provide meaningful insights but not so large that it becomes difficult to manage and analyze the data (Fox, Hunn, and Mathers, 2009; Kadam & Bhalerao, 2010; Hsieh, Bloch, and Larsen, 1998)

$$Sample\ size, n = N \times \left(\frac{\frac{(z)^2 \times p \times q}{(e)^2}}{(N-1) + \frac{(z)^2 \times p \times q}{(e)^2}} \right) \quad (3.1)$$

Where

n = minimum returned sample size

N = the population sizes

z = critical value of the normal distribution at the required confidence level

e = the desired level of precision

p = the estimated proportion of the population which has the attribute to the question

q = 1- p

$$n = 130 \times \left(\frac{\frac{(1.96)^2 \times 0.5 \times (1-0.5)}{(0.5)^2}}{(130-1) + \frac{(1.96)^2 \times 0.5 \times (1-0.5)}{(0.5)^2}} \right)$$
$$= 98$$

The target group for this study comprises senior adults aged over 60 years old, and the critical factors to be considered in product development are the function, shape, color, and size of the shopping cart that they use when grocery shopping. A total of 130 questionnaires were distributed to potential customers, and based on the calculation, a sample size of 98 respondents is sufficient. This research received 100 responses, which is more than the required sample size.

3.3 Data Collection and Analysis

The survey was conducted using an online survey platform, and out of 130 sets of questionnaires launched, a total of 100 respondents participated. The target group for this questionnaire was senior adults with experience in grocery shopping. The first part

of the questionnaire focused on collecting general information, as shown in Table 3.1. Some examples of questions that aimed to identify customer's general information are:

1. What is your gender?

2. How old are you?

3. What is your occupation?

4. What is your marital status?

5. How many members are there in your household?

6. What is your monthly salary?

Table 3.1 Descriptive Analysis of Respondents (General Information)

Gender	**Number of Respondents**	**Percentage**
Female	58	58
Male	42	42
Age	**Number of Respondents**	**Percentage**
51-60	44	44
61-70	52	52
71-80	3	3
>80	1	1
Occupation	**Number of Respondents**	**Percentage**
Government Official	31	31
Government Employee	1	1
Retired Government	39	39
Official	4	4
Company Employee	1	1
State Enterprise	15	15
Employee	6	6
Self-Employed	1	1
Hose Maker	1	1
Employee	1	1
Agriculturist		
Unemployed		

Marital Status	Number of Respondents	Percentage
Single	10	10
Married	78	78
Divorced/Widowed	10	10
Separated	2	2
N/A	0	0
Members in Household	**Number of Respondents**	**Percentage**
1	7	7
2	17	17
3	30	30
4	29	29
5	12	12
>5	5	5
Monthly Salary	**Number of Respondents**	**Percentage**
0 – 15,000 Baht	9	9
15,001 – 25,000 Baht	14	14
25,001 – 35,000 Baht	17	17
35,001 – 50,000 Baht	27	27
50,001 – 100,000 Baht	26	26
> 100,000 Baht	7	7

Question in the second part is problems and activities as shown in Table 3.2(a) and 3.2(b), the second part of the questionnaire focuses on identifying the problems and activities of the target group. The questions aim to understand the leisure activities that the respondents engage in, as well as the serious health problems and obstacles they face in their daily lives. The main questions raised for identifying about customer's problems and activities are listed below.

Question 1: What are your four favorite leisure activities?

Question 2: What are three serious health problems for you?

Question 3: What are three obstacles for living in daily life?

Table 3.2(a) Descriptive Analysis of Respondents (Problems and Activities)

Four Favorite Leisure Activities	**Number of Respondents**	**Percentage**
Cooking	43	10
Traditional Shopping	67	16.75
Online Shopping	23	5.75
Housecleaning	40	10
Travelling	63	15.75
Outdoor Exercise	46	11.5
Indoor Exercise	15	3.75
Religious Activities	16	4
Language Learning	2	0.5
Communication with Family and Friends	59	14.75
Art Activities	0	0
Musical Activities	1	0.25
Embroidery	6	1.5
Singing	13	3.25
Gardening/Planting	4	1
Watching TV/Movies	1	0.25
Working	1	0.25
Three Serious Health Problems	**Number of Respondents**	**Percentage**
Eyes and Vision	52	17.3
Movement	75	25
Hearing	22	7.3
Respiration	8	2.7
Mental	11	3.7
Digestive System	37	12.3
Excretory System	19	6.3
Nervous System	29	9.7
Circulatory System	26	8.7
Reproductive System	1	0.3
Hormones	8	2.7
Taste	5	1.7
Pains and Aches	2	0.7
Allergy	2	0.7
Amnesia	2	0.7
None	1	0.3

Table 3.2(b) Three obstacles for living

Three Obstacles for Living	Number of Respondents	Percentage
Technology	54	18
Fine Motor Skills	19	6.3
Gross Motor Skills	36	12
Small Button Pressing	42	14
Uncomfortable Product	61	20.3
Environment and Safety	39	13
Recognition	46	15.3
Pains and Aches	1	0.3
None	1	0.3

In the final part of the questionnaire, respondents were asked about their preferences for grocery shopping products as shown in Table 3.3. The following questions were asked to identify their product preferences:

Question 1: What are two grocery shopping products that you find useful?

Question 2: What are two grocery shopping products that you find interesting?

Question 3: What is your preferred color for grocery shopping products?

Table 3.3 Descriptive Analysis of Respondents (Product)

Two Useful Products	Number of Respondents	Percentage
Wheelchair	56	28
Walker	27	13.5
Clutches	29	14.5
Cane	63	31.5
Walking stick	13	6.5
None	12	6
Two Interesting Products	**Number of Respondents**	**Percentage**
Multifunctional Folding Shopping Cart	36	18
Portable Lift-up Seat	33	16.5
Fall Detector	27	13.5
Exercise Equipment for Seniors	50	25
Smart Tracker	31	15.5
Reminder Gadget	20	10
None		1.5

Color	Number of Respondents	Percentage
Classic	38	38
Colorful	11	11
Romantic	14	14
Beige tone	37	37

3.4 Importance level

The participants were asked to rate the importance of specific features in a shopping cart using a Likert scale from 1 to 5, where 1 represents "not important at all" and 5 represents "extremely important." The features included in this section are listed in Table 3.4. Participants were also given the opportunity to provide any additional feedback or suggestions for the design of a new shopping cart.

Table 3.4 Level of Importance of Products (Sarkar, & Chakrabarti, 2011)

Code	Points in a scale of 5	Level of importance	Type of importance	Product examples
A	5 (>4.0 - 5.0)	Extreme	• Lifesaving drugs, life support systems • Patient life support system • Medical equipment, medicine	Mechanical ventilator, defibrillator, heart/lung bypass machine (Oxygen cylinder, pacemakers)
B	4 (>3.0 - 4.0)	Very high	• Essential for daily activities • Compulsory daily activities	Water, Taking food, Using restroom
C	3 (>2.0 - 3.0)	High	• Accommodation • Social communication • Banking transactions	House, clothes, internet, computer, smartphone, EDC machine, Pen, Belt, Spectacles, Shoes
D	2 (>1.0 - 2.0)	Medium	• Household appliances • Machines for daily needs	Air conditioning system, refrigerator, washing machine
E	1 (0.0 - 1.0)	Low	• Recreation activities • Entertainment systems • Recreation systems	Television, Comics, Books, Computer games, Bowling, Go-carting

3.4.1 Usefulness of a Product

The usefulness of a product can only be truly evaluated through its actual usage, rather than just perceived usefulness. Therefore, the proposed method for measuring the usefulness of a product is based on evaluating its actual use. The parameters used in this method include various factors that are explained below. (Sarkar, & Chakrabarti, 2011)

$$Usefulness\ (U) = \text{Level of importance (L)x Rate of popularity of use (R) x Frequency of usage (F) x Duration of use or Duration of benefit per usage (D)} \quad (3.2)$$

For foldable shopping cart:

Importance of use (L): 2.5/5

Rate of popularity or use (R): 18/100

Rate of use (F x D): 3/24

Usefulness (U): (2.2/5) x (18/100) x (3/24) = 0.01125

For portable lift-up seat:

Importance of use (L): 2/5

Rate of popularity or use (R): 16.5/100

Rate of use (F x D): 1/24

Usefulness (U): (2/5) x (16.5/100) x (1/24) = 0.000275

For smart tracker:

Importance of use (L): 1.5/5

Rate of popularity or use (R): 15.5/100

Rate of use (F x D): 24/24

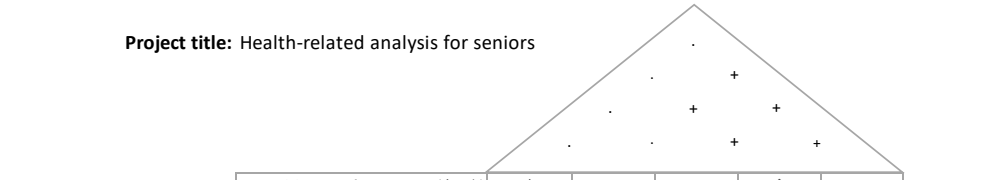
Usefulness (U): (1.5/5) x (15.5/100) x (24/24) = 0.0465

The results show that the ratio of usefulness for the products is as follows: foldable shopping cart, portable lift-up seat, and smart tracker have a usefulness ratio of 40:1:169, respectively. Based on this condition, the smart tracker is the most useful among the three items.

3.5 Quality Function Deployment (QFD)

It appears that the functional requirements used in this research were determined from an engineering perspective and include multifunctionality, product dimensions, material selection, durability, and shape. These requirements are interrelated and their correlation can be classified into three levels, represented by symbols: positive correlation (+), negative correlation (-), and no correlation (·). The strength of the relationship between customer requirements (What's) and engineering specifications (How's) is represented using numbers ranging from 9 (strongest relationship) to 1, and none (Baxter, 2015; Dieter & Schmidt, 2017; Pahl, Beitz, Feldhusen, and Grote, 2013; Roebuck, 2014; Ulrich & Eppinger, 2017)

The first part of the questionnaire results pertains to health-related problems faced by seniors. The questions aim to identify health issues that impact seniors' daily lives and require treatment. The customer requirements assessed include vision, movement, nervous system, hearing, digestive system, excretory system, and mental health. Analysis of the weighted scores indicates that movement is the most important problem faced by seniors, followed closely by vision. This suggests that movement is a significant challenge for seniors when engaging in daily activities. In terms of engineering specifications, the analysis shows that shape is the most important factor, followed by material used, product dimension, durability, and multi-functionality (Figure.3.2-3.3).



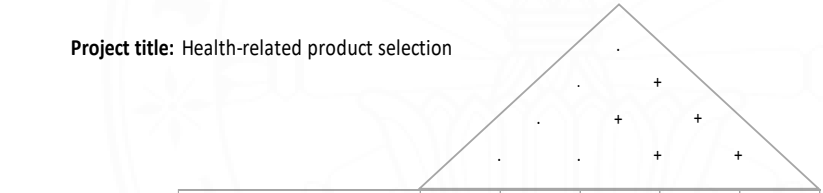
Project title: Health-related analysis for seniors

Correlation:		
+	.	-
Positive	No correlation	Negative

Relationships:			
9	3	1	0
Strong	Moderate	Weak	None

	1: low, 5: high Customer importance rating	Functional Requirements (How's) → Customer Requirements - (What's) ↓	Multifucntional	Product Dimension	Material Used	Durability	Shape	Weighted Score
		Desired direction of improvement (↑,0,↓)	↓	0	0	↑	0	
1	4	Vision	3	3	9	3	9	108
2	5	Movement	3	9	9	9	9	195
3	3	Nervous System	3	3	3	0	3	36
4	2	Hearing	3	0	3	0	3	18
5	3	Digestive System	0	3	0	0	3	18
6	2	Excretory System	0	3	0	0	3	12
7	1	Mental Health	9	0	1	0	0	10
		Technical importance score	51	81	97	57	111	397
		Importance %	13%	20%	24%	14%	28%	100%
		Priorities rank	**5**	**3**	**2**	**4**	**1**	

Figure 3.2 Health-Related Problem Analysis for seniors



Project title: Health-related product selection

Correlation:		
+	.	-
Positive	No correlation	Negative

Relationships:			
9	3	1	0
Strong	Moderate	Weak	None

	1: low, 5: high Customer importance rating	Functional Requirements (How's) → Customer Requirements - (What's) ↓	Weight	Dimension	Material Used	Durability	Shape	Weighted Score
		Desired direction of improvement (↑,0,↓)	↓	0	0	↑	0	
1	4	Foldable shopping cart	9	9	3	3	9	132
2	3	Lift-up seat	3	9	9	3	9	99
3	2	Fall detecction	1	1	0	0	3	10
4	5	Exercise equipment for senoirs	3	9	9	9	3	165
5	3	Reminder	1	1	0	0	3	15
6	1	Tracker	1	1	0	0	3	5
		Technical importance score	66	114	84	66	96	426
		Importance %	15%	27%	20%	15%	23%	100%
		Priorities rank	**4**	**1**	**3**	**4**	**2**	

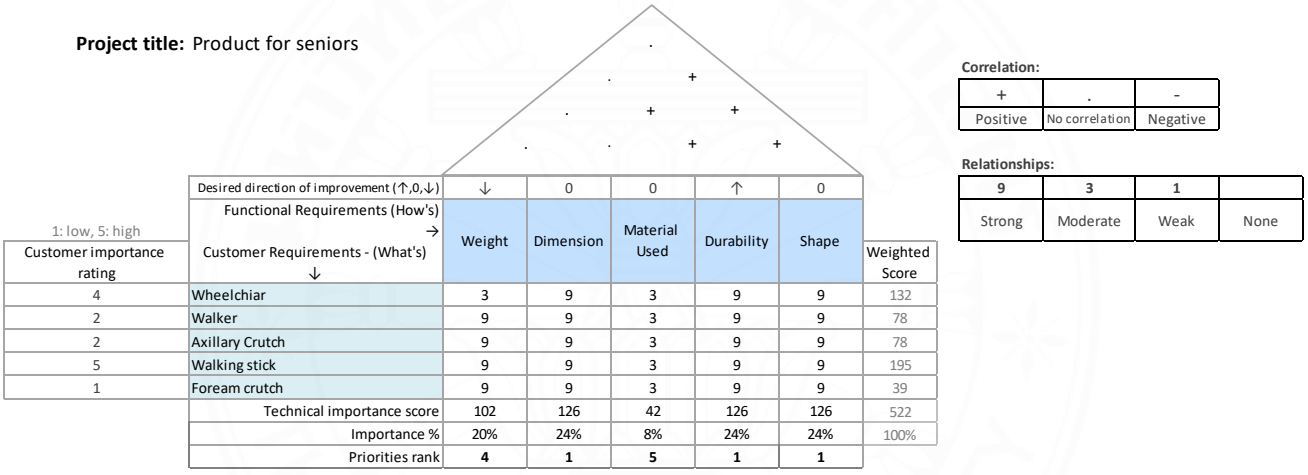
Figure 3.3 Health-Related Product Selection

The second part of the questionnaire results focuses on health-related product selection for seniors. These questions aim to identify which health-related products seniors find useful. The customer requirements include foldable shopping carts, lift-up seats, fall detection devices, exercise equipment for seniors, reminders, and trackers. The weighted scores indicate that exercise equipment for seniors is the most important followed by foldable shopping carts. This suggests that senior adults are more health-conscious and interested in maintaining an active lifestyle, while still placing importance on grocery shopping. Upon analyzing the percentage of importance, the engineering specifications reveal that shape is the most important factor followed by the *material used, product dimension, durability*, and *multifunctionality.*

Simply saying that it is interesting to see that exercise equipment for seniors is highly valued by the target group, which indicates that they prioritize their physical health and well-being. Additionally, the high ranking of the foldable shopping cart suggests that seniors are still active in grocery shopping and require practical and easy-to-use tools to assist them. The engineering specifications, as determined by the study, indicate that the shape of the product is the most important factor, followed by the material used, product dimensions, durability, and multi-functionality. These results suggest that product design should prioritize ergonomic and user-friendly shapes, high-quality and durable materials, and optimal product dimensions to meet the needs of senior adults.

Key considerations: it is important to note that the engineering specifications should be considered in the design of health-related products for seniors, as they play a crucial role in ensuring that the products meet the needs and requirements of the users. Furthermore, the results from this part of the questionnaire suggest that the product designers should focus on creating products that not only provide health benefits but also make daily activities, such as grocery shopping, easier for seniors.

Some potential design considerations that could be derived from the results include creating exercise equipment for seniors that is compact, lightweight, and easy to use, as well as designing foldable shopping carts that are sturdy, easy to maneuver, and have ample storage space. Additionally, it may be beneficial to incorporate features such as fall detection and reminders into the products, as these could help prevent accidents and promote better health outcomes for seniors (Chen, Xue, and Ding, 2018; Hong, Cho, and Kim, 2017; Kim, Kim, and Kim, 2019; Sheng, Shi, & Wang, 2018; Wu, Lin, and Xu, 2020)



Project title: Product for seniors

Correlation:

+	.	-
Positive	No correlation	Negative

Relationships:

9	3	1	
Strong	Moderate	Weak	None

	1: low, 5: high Customer importance rating	Functional Requirements (How's) → Customer Requirements - (What's) ↓	Weight	Dimension	Material Used	Durability	Shape	Weighted Score
		Desired direction of improvement (↑,0,↓)	↓	0	0	↑	0	
1	4	Wheelchiar	3	9	3	9	9	132
2	2	Walker	9	9	3	9	9	78
3	2	Axillary Crutch	9	9	3	9	9	78
4	5	Walking stick	9	9	3	9	9	195
5	1	Foream crutch	9	9	3	9	9	39
		Technical importance score	102	126	42	126	126	522
		Importance %	20%	24%	8%	24%	24%	100%
		Priorities rank	**4**	**1**	**5**	**1**	**1**	

Figure 3.4 Product for Seniors

The last part of the questionnaire results focuses on existing products used by seniors to support their bodies. The customer requirements include wheelchair, walker, axillary crutch, walking stick, and forearm crutch. The weighted score shows that walking stick is the most commonly used product, followed by the wheelchair. After analyzing the percentage of importance, the engineering specifications reveal that dimension, durability, and shape are the most important factors, followed by weight and material used.

3.6 Bartlett's Test

Bartlett's test is a statistical test used to determine whether two or more populations have equal variances. It is important to assess the equality of variances because it is an assumption of many statistical tests, including the t-test and analysis of variance (ANOVA). Bartlett's test is based on the chi-square distribution and can be used for both normal and non-normal populations. The test involves comparing the sum of squared deviations of the observations from their respective means to what would be expected if the variances were equal. If the test statistic is large and the p-value is small, it suggests that the variances are not equal. (Bartlett, 1937; Montgomery, Peck, and Vining, 2012; Ruppert, 2011; Weerahandi, 2011; Zar, 2010)

Correlation Matrix[a]

		Your health problems effect to daily life.	You have power to do activities.	You feel satisfied when you can do all the tasks.	You can go everywhere you want.	You feel safe when do indoor/outdoor activities.	You have time to relax.	You feel satisfy when transporting to somewhere.	You feel satisfied with your health.	You satisfied with your quality of life scale.
Correlation	Your health problems effect to daily life.	1.000	-.347	.018	-.334	-.214	-.123	-.242	-.287	-.177
	You have power to do activities.	-.347	1.000	.453	.511	.387	.253	.417	.543	.439
	You feel satisfied when you can do all the tasks.	.018	.453	1.000	.254	.407	.349	.354	.398	.430
	You can go everywhere you want.	-.334	.511	.254	1.000	.526	.226	.591	.590	.527
	You feel safe when do indoor/outdoor activities.	-.214	.387	.407	.526	1.000	.577	.726	.611	.580
	You have time to relax.	-.123	.253	.349	.226	.577	1.000	.507	.359	.295
	You feel satisfy when transporting to somewhere.	-.242	.417	.354	.591	.726	.507	1.000	.565	.541
	You feel satisfied with your health.	-.287	.543	.398	.590	.611	.359	.565	1.000	.618
	You satisfied with your quality of life scale.	-.177	.439	.430	.527	.580	.295	.541	.618	1.000
Sig. (1-tailed)	Your health problems effect to daily life.		.000	.429	.000	.016	.111	.008	.002	.039
	You have power to do activities.	.000		.000	.000	.000	.006	.000	.000	.000
	You feel satisfied when you can do all the tasks.	.429	.000		.005	.000	.000	.000	.000	.000
	You can go everywhere you want.	.000	.000	.005		.000	.012	.000	.000	.000
	You feel safe when do indoor/outdoor activities.	.016	.000	.000	.000		.000	.000	.000	.000
	You have time to relax.	.111	.006	.000	.012	.000		.000	.000	.001
	You feel satisfy when transporting to somewhere.	.008	.000	.000	.000	.000	.000		.000	.000
	You feel satisfied with your health.	.002	.000	.000	.000	.000	.000	.000		.000
	You satisfied with your quality of life scale.	.039	.000	.000	.000	.000	.001	.000	.000	

a. Determinant = .018

Figure 3.5 Correlation Matrix

In order to identify the related problems experienced by seniors in their daily lives, a correlation matrix was analyzed using factors obtained from customer surveys and questionnaires. The correlation matrix provides information on how these factors are related to each other, with higher values indicating a stronger correlation. The results show that the factors with the strongest correlation are feeling safe when engaging in indoor/outdoor activities and feeling satisfied when transporting, with a correlation matrix value of 0.726. The next highest correlations were found between feeling satisfied with health and feeling satisfied with the quality-of-life scale, both with a correlation matrix value of 0.618.

These correlations were used to inform the design of a final product. The factors that require attention are feeling safe when engaging in indoor/outdoor activities, feeling satisfied when transporting, feeling satisfied with health, and feeling satisfied with the quality-of-life scale.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.864
Bartlett's Test of Sphericity	Approx. Chi-Square	384.169
	df	36
	Sig.	.000

Figure 3.6 KMO and Barlett's Test

The result is applied with the hypothesis test. For this test the hypothesis is shown as:

H_0: Correlation Matrix = 1

H_1: Correlation Matrix ≠ 1

When the significance value is less than 0.05, H_0 is rejected. This can be concluded that the correlation matrix ≠ 1. The result of this test obtained is shown in Figure 3.5

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Quality function deployment (QFD) analysis

In this section, a Quality Function Deployment (QFD) analysis is performed to compare the importance ratings of the new shopping cart model with those of other existing models. Three existing models are chosen based on their popularity among the target customers, and each model has its own important function. Competitor 1's main function is to provide storage space under the seat with a brake system, while competitor 2's main function is to have a large storage bag for carrying groceries and other items. Competitor 3's main function is to provide portable storage with multiple useful functions, and this model serves as a reference model for creating the new design. Based on the analysis, the new model receives a higher importance rating from customers, indicating that it better meets their needs than the current models

Project title: Shopping Cart for Seniors
Project leader:
Date:

Correlation:

+	.	-
Positive	No correlation	Negative

Relationships:

9	3	1	
Strong	Moderate	Weak	None

	1: low, 5: high	Desired direction of improvement (↑,0,↓)	↓	0	0	↑	0		Competitor Analysis			
	Customer importance rating	Functional Requirements (How's) → / Customer Requirements - (What's) ↓	Weight	Dimension	Material Used	Mean lifetime	Shape	Weighted Score	Competitor 1	Competitor 2	Competitor 3
1	5	Container (Basket)	9	9	3	3	9	165	5	5	5
2	2	Cooling System		1	9	3	1	28	1	1	1
3	4	Light	1	3	1	3		32	1	1	1
4	5	Brake System		3	3	3		45	5	1	5
5	3	Foldable		9	1	9	9	84	1	3	5
6	3	Seat	9	9	3	3	9	99	4	1	4
7	1	Lift Up System	9	9	9	9	9	45	1	1	1
8	3	Sensor		3	1	3		21	1	1	1
		Technical importance score	76	128	64	84	101	519	19	14	23
		Importance %	15%	25%	12%	16%	19%	87%			
		Priorities rank	4	1	5	3	2				

Figure 4.1 Shopping Cart for Senior

4.2 Concept of 3F's approach for the new product

The research focus of this project is on developing a functional and aesthetically pleasing shopping cart for senior citizens. To achieve this goal, existing products were analyzed, and the "Health Smart Rollator Walker" from Alibaba was selected as a reference model. To ensure the functionality of the new product, various engineering methods such as Product Design and Development (PDD), Quality Function Deployment (QFD), and Bartlett's Test were applied. In this chapter, the 3F's approach (Form, Fit, and Function) will be discussed to highlight the importance of these aspects in product development. The term "form-fit-function" (FFF) is commonly used in manufacturing to describe the essential characteristics of a component.

4.2.1 Form

The dimensions of the product are approximately 26 x 33 x 31-36 inches. Most of the components have rounded corners, which were designed to make customers feel comfortable when using the product. The product weighs around 8 kg and has a load capacity of 130 kg, making it lightweight and easy to move in small spaces.

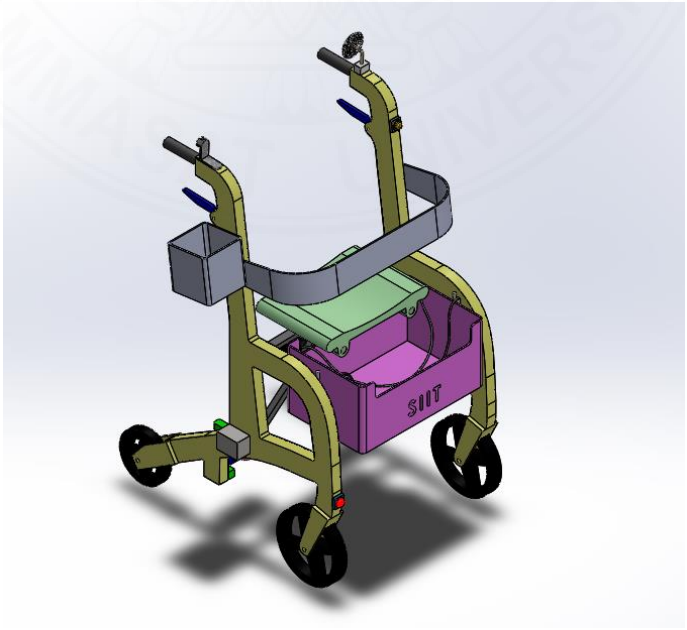


Figure 4.2 New Model

4.2.2 Fit

The product components are categorized into two main parts, namely the structural or main part and the functional part. The structural or main part includes the back supporter, body, and seat. On the other hand, the functional part consists of several components such as the basket, fan, brake, small storage basket, foot supporter, smartphone holder, battery, light, and sensor.

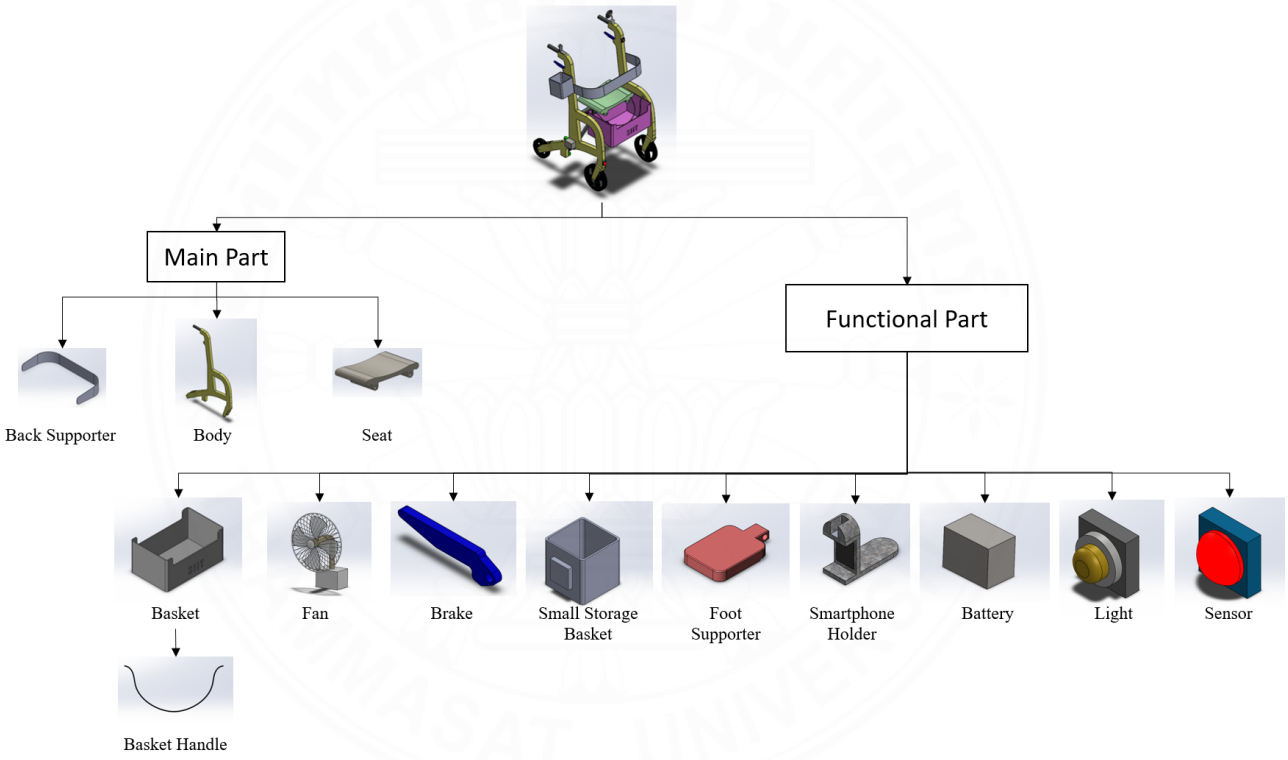


Figure 4.3 Bill of Materials

4.2.3 Function

This product has been designed to support senior citizens during physical activities, particularly when grocery shopping, in order to enhance their safety. The new design features various useful functions such as a seat, lift-up plate, brake system, lighter, sensor, cooling system, and smartphone holder. Additionally, the product can be folded for convenient storage in small spaces.

4.3 Detailed Design

To create a new design for a senior shopping cart, it is important to consider the characteristics of each component. In this section, we will provide a detailed explanation of each component's function. The figures below are created from 3D CAD models to show the physical shape of each component from different perspectives.

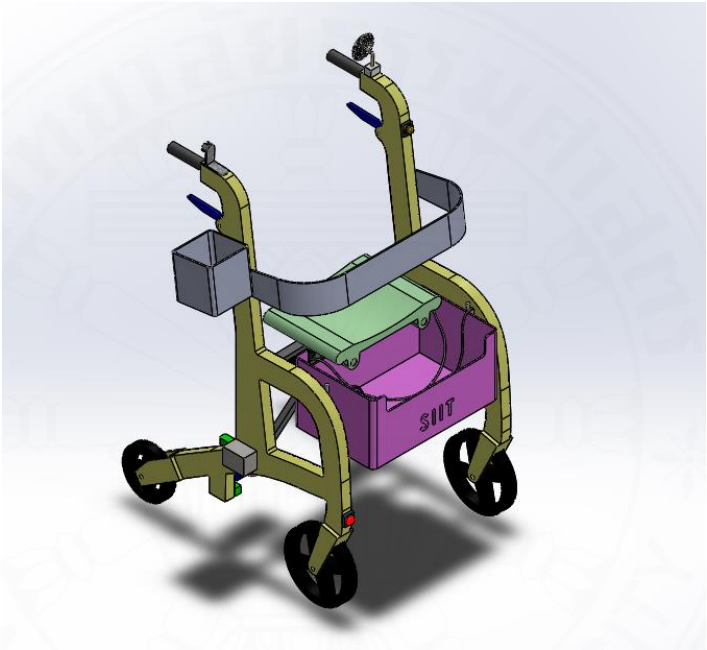


Figure 4.4 Isometric view of product

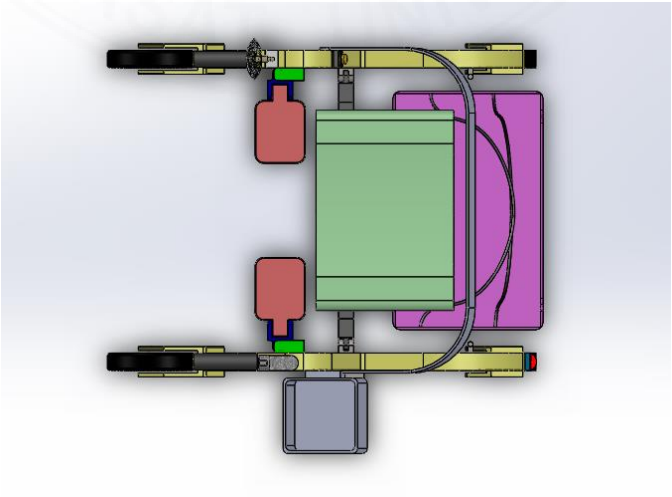


Figure 4.5 Top view of product

Figure 4.6 Side view of product

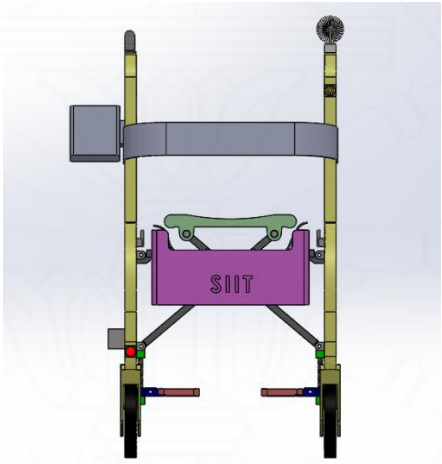


Figure 4.7 Front view of product

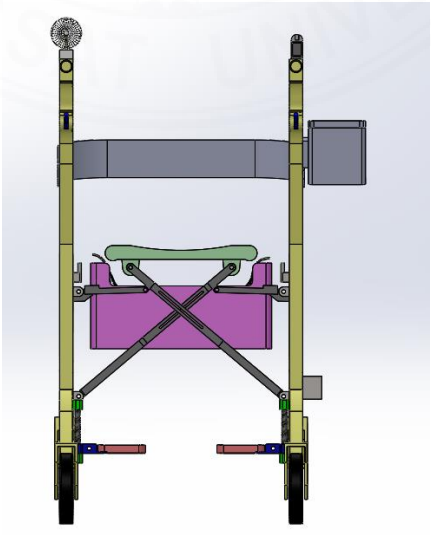
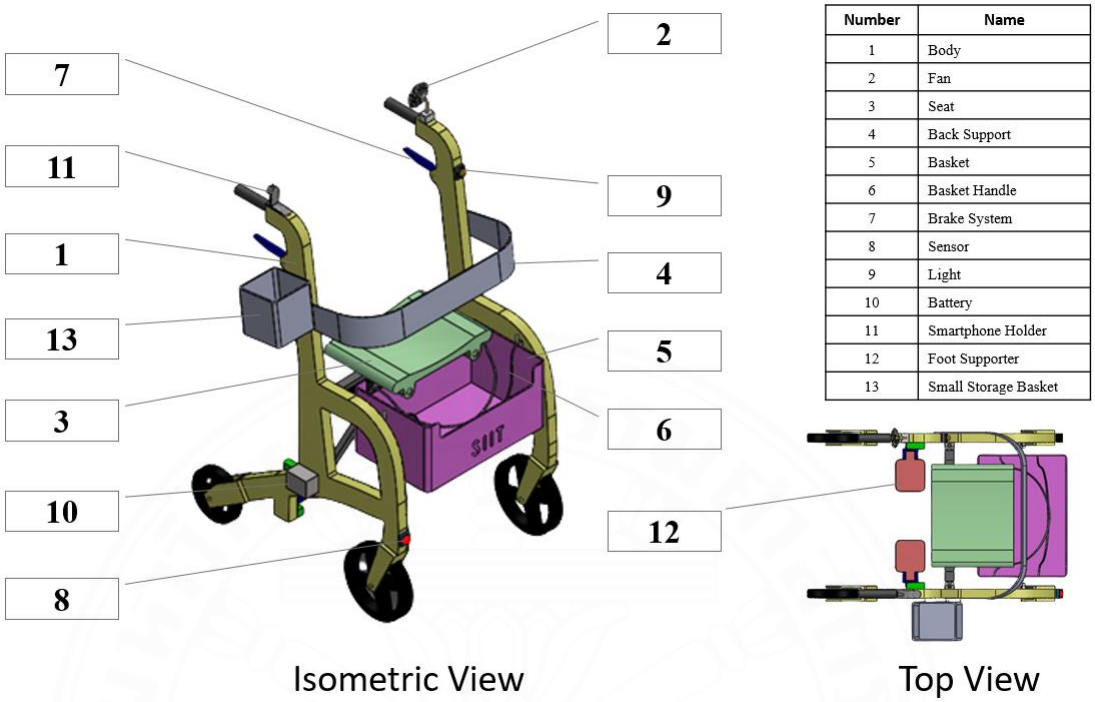


Figure 4.8 Back view of product



Number	Name
1	Body
2	Fan
3	Seat
4	Back Support
5	Basket
6	Basket Handle
7	Brake System
8	Sensor
9	Light
10	Battery
11	Smartphone Holder
12	Foot Supporter
13	Small Storage Basket

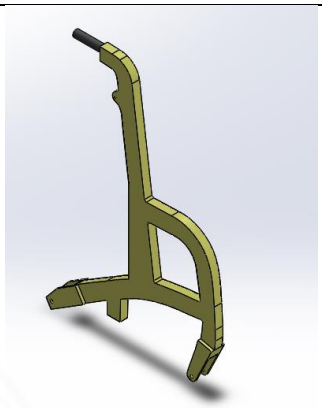
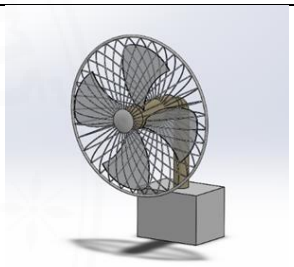
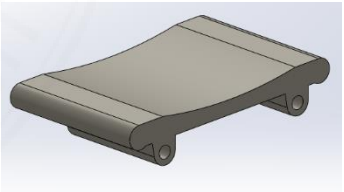
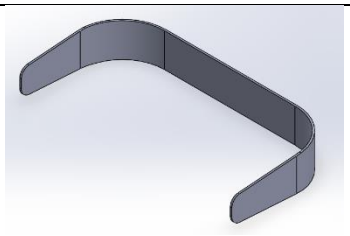
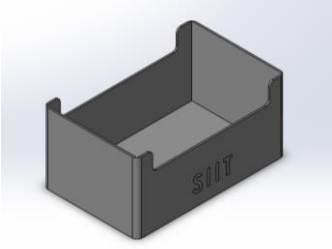
Figure 4.9 Design Components

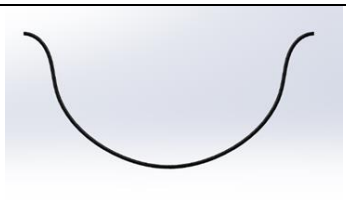
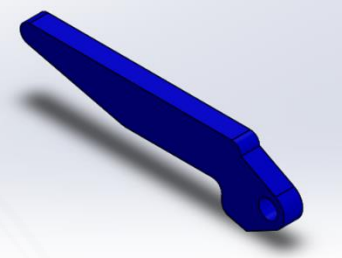
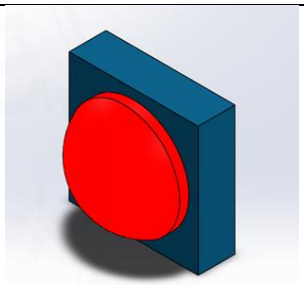
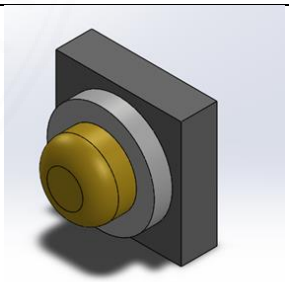
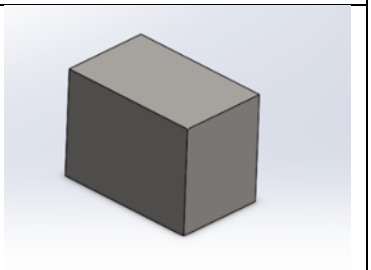
The functional components that are used to support senior activities consists of 13 parts which are body, fan, seat, back supporter, basket, brake system, basket handle, sensor, lighter, battery, smartphone holder, foot plate, and small storage bag. Moreover, some additional details about the functional components of the senior shopping cart:

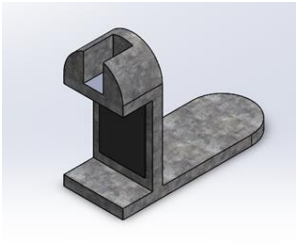
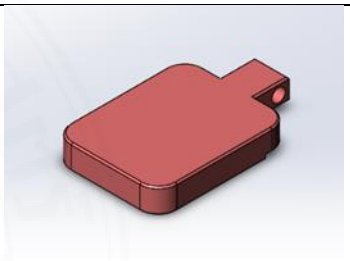
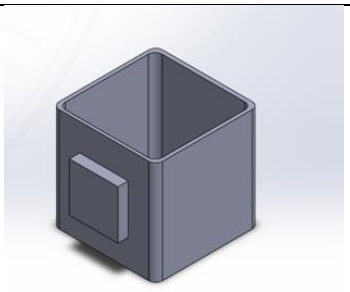
- The body is the main structure of the cart, which supports all other components and provides stability during use.
- The fan is a useful feature to keep seniors cool and comfortable during outdoor activities.
- The seat provides a place to rest when needed and also serves as a platform to lift items onto the cart.
- The back supporter is designed to provide additional support and stability to seniors during use.
- The basket is a large storage area where seniors can place items they wish to purchase or carry with them.
- The brake system is a crucial safety feature that allows seniors to stop and secure the cart when needed.

- The basket handle provides an easy and comfortable grip for seniors to maneuver the cart.
- The sensor is a feature that can detect obstacles and alert seniors to potential hazards.
- The lighter is a useful feature to illuminate the path during low-light conditions or to help seniors find items within the cart.
- The battery is used to power the cart's features such as the fan, sensor, and light.
- The smartphone holder is a convenient feature that allows seniors to keep their phone close at hand for communication and other purposes.
- The foot plate provides additional stability and support when standing on the cart to reach high shelves.
- The small storage bag is a useful feature to store small items such as keys, wallet, or medication.

Table 4.1 Design Components

Component	Function/Description	Picture
1.Body	The body component is designed in a curved shape and serves as the main structure of the model. It is designed to support the smaller components that are connected to it. The body component is also designed to help regulate body temperature for users in hot environments and prevent heat stroke, which is especially important for elderly users who may not adjust as well to sudden temperature changes.	
2.Fan	This component was designed to incorporate a cooling system to decrease the body temperature for users in hot environments and help prevent heat stroke, which can be particularly dangerous for the elderly as they are less able to adjust to sudden changes in temperature.	
3. Seat	The seat component is designed to support the user's body and is shaped in a curvature to provide maximum comfort while seated.	
4. Back Support	The back supporter component is designed to support the user's back and provide fall protection in some uncontrolled conditions.	
5. Basket	The basket component serves as a container to keep items in place. It is located under the seat, so as not to interfere with other activities. The design allows for larger items to be easily taken out and stored, supporting grocery shopping activities.	

Component	Function/Description	Picture
6. Basket Handle	The basket handle is typically attached to the basket and used for carrying the shopping cart in portable mode.	
7. Brake System	This component is designed to provide a braking system to stop the shopping cart when needed, ensuring the safety of the user. It is also used when the user wants to sit on the seat, providing additional stability and preventing the cart from rolling away.	
8. Sensor	This component serves as a safety feature and functions similarly to a car's sensor system. If there is an object blocking the path of the shopping cart, the sensor will activate and generate an audible sound and blinking lights to alert the user to be more cautious.	
9. Light	The light component is designed to provide visibility in low-light environments, such as at night or in dark indoor spaces. It helps the user to see the direction more clearly and can also make them more visible to others who are sharing the same path. This increases safety for the user and those around them.	
10. Battery	To be more specific, the battery is used to power the fan, light, and sensor, and can be recharged through a power outlet. It is designed to be easily accessible and removable for charging or replacement.	

Component	Function/Description	Picture
11.Smartphone Holder	The smartphone holder is an essential component of the senior shopping cart. Its function is to securely hold and position a smartphone. This allows seniors to easily access their phone for communication, navigation, or other needs while using the cart. The holder is designed to be easily adjustable to fit different sizes and types of smartphones.	
12.Foot Supporter	Lifting is one of the functions to assist users in reaching overhead items in the grocery store. The foot supporter is a component that is connected to the lifting system, allowing users to step on it and lift themselves up to reach the items. This feature is designed to reduce the risk of falls and injuries from overreaching, especially for seniors with mobility issues.	
13. Small Storage Basket	This component is a small storage bag that is designed to keep small items in place. It is located near the handle of the product, making it easily accessible for the user.	

4.4 Finite Element Analysis (FEA)

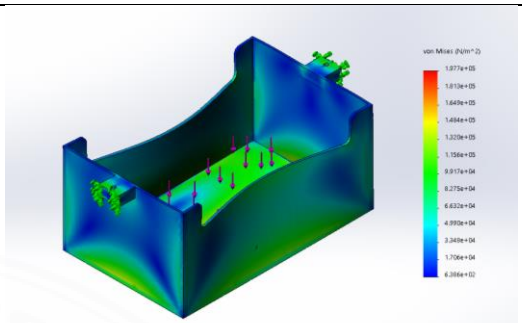
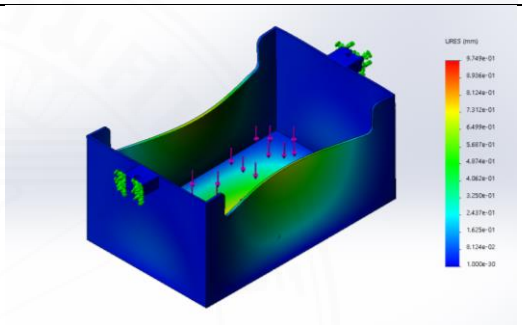
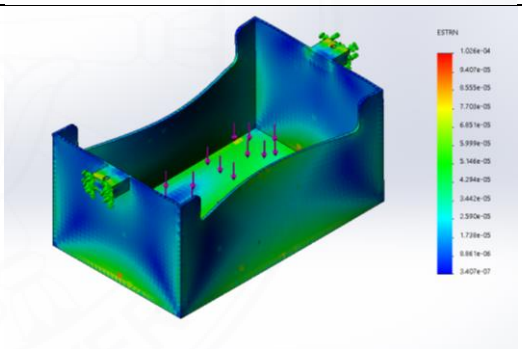
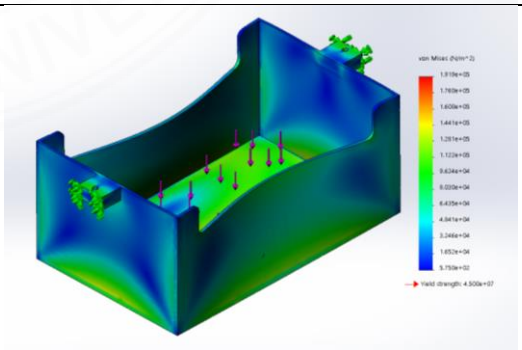
After classifying the desired model to be main components and sub-components, the detailed design stage has been established where the “Finite element analysis or FEA” that is a numerical method used to simulate and predict the behavior of objects under various physical conditions, is the key tool for identifying the force applied on the area of interest. In this study, the **basket** and **foot supporter** components

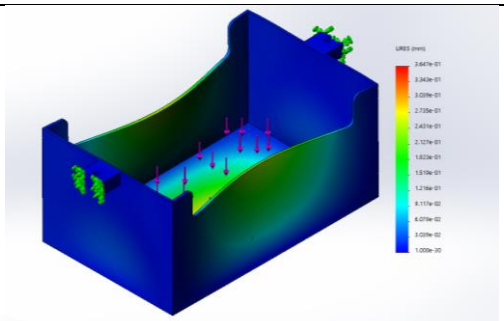
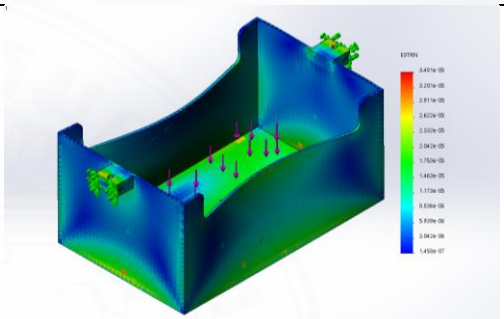
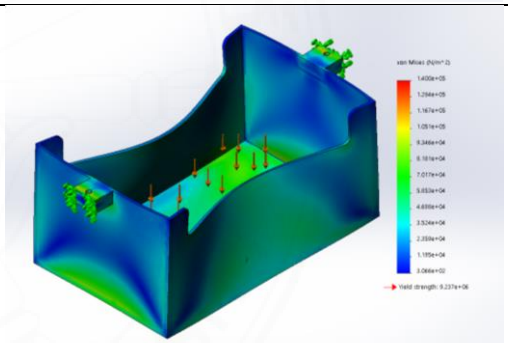
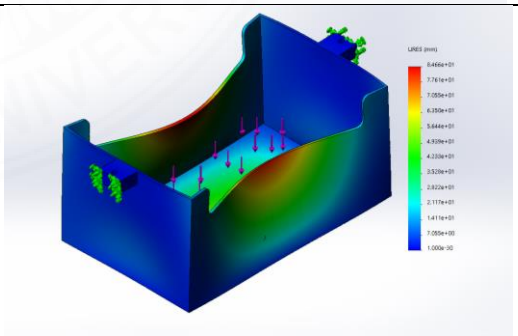
were analyzed using FEA due to their direct support of force. The analysis required obtaining results of stress, strain, and displacement before creating a prototype. The basket component was tested with three material types: high density polyethylene (HDPE), acrylic, and rubber with a force of 100 N. The foot supporter was tested with three material types: alloy steel, alumina, and stainless steel with a force of 600 N. The results of the analysis are presented in the tables below.

Besides, for obtaining clean and clear details of this FEA, some additional suggestions are mentioned and discussed:

- It might be helpful to include some visual aids, such as graphs or diagrams, to better illustrate the results of the finite element analysis. This could help readers understand the stress, strain, and displacement data more easily.
- The design team could also discuss some of the limitations or potential sources of error in the finite element analysis. For example, were there any assumptions made about the materials or the forces applied that might affect the accuracy of the results?
- Another idea is to explain how the results of the finite element analysis were used to improve the design of the shopping cart. Did the analysis reveal any areas of weakness or stress concentration that needed to be addressed? How were these issues resolved in the final design?
- Finally, the design team could discuss some of the potential benefits of using finite element analysis in the design process. *For example*, how does this approach compare to more traditional methods of testing and prototyping? What are some of the advantages of using simulations and models to predict how a design will perform under different conditions?
- The technique involves dividing the structure of an object into small pieces or elements and then reconnecting them at nodes to create a set of algebraic equations that can be used to perform finite element analysis. FEA is commonly used to identify vulnerabilities in design prototypes and to ensure the structural integrity of a product.

Table 4.2 FEA of Container (Basket)

Material	Result	Visualizasion
HDPE (Force 100 N)	Stress: - Low to Medium - Force mostly occur inside the part.	
	Displacement: - Very low to Low - No movement after putting in force	
	Strain: - Low to Medium - Strain mostly occur inside the part.	
Acrylic (Force 100 N)	Stress: - Low to Medium - Force mostly occur inside the part.	

Material	Result	Visualizasion
	Displacement: - Very low to Low - No movement after putting in force	
	Strain: - Low to Medium - Strain mostly occur inside the part.	
Rubber (Force 100 N)	Stress: - Low to Medium - Force mostly occur inside the part.	
	Displacement: - Medium to High - Have chance to move after putting in force	

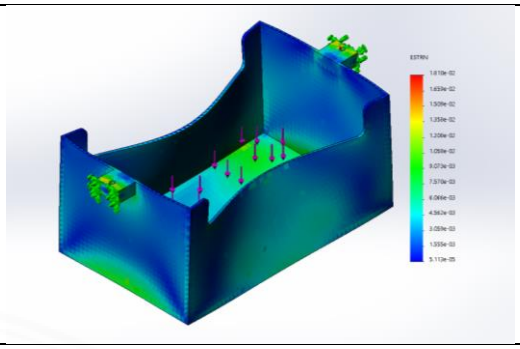
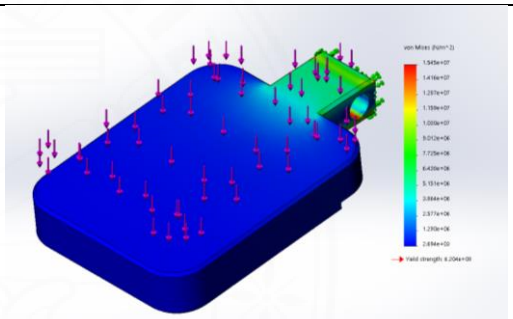
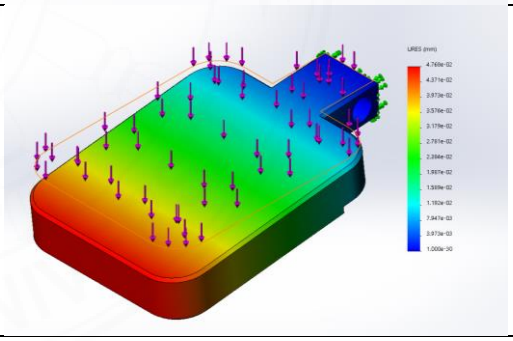
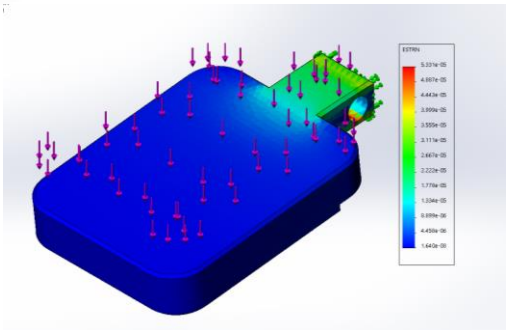
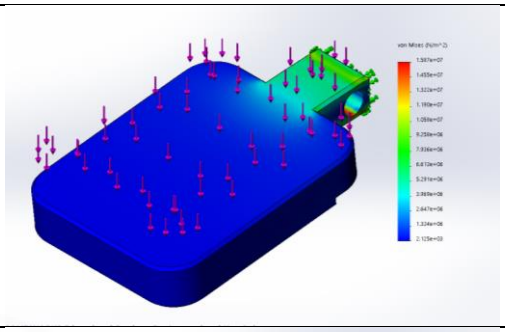
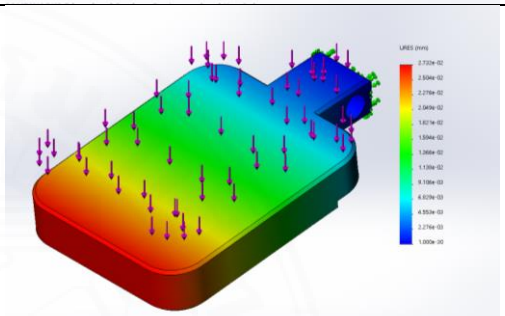
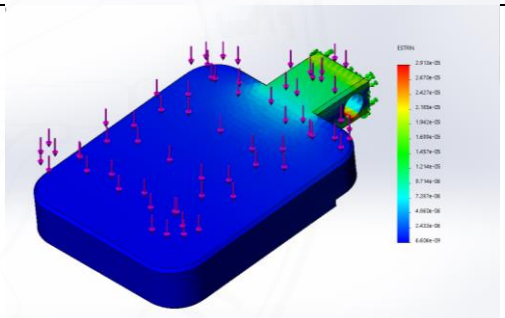
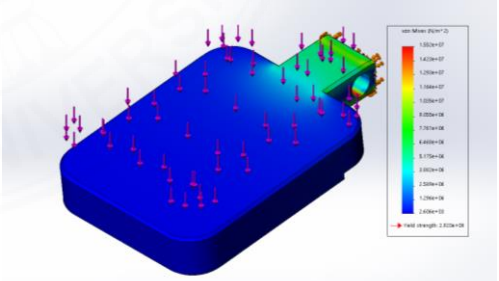
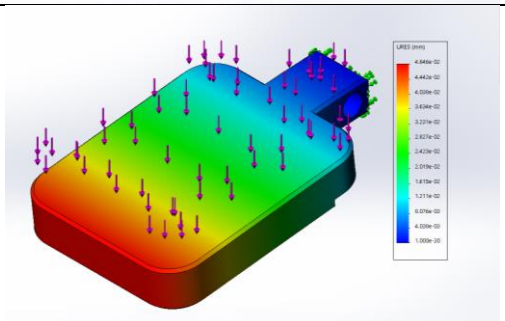
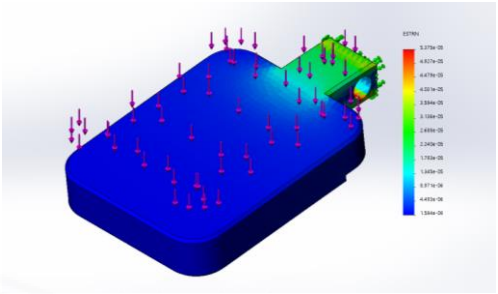
Material	Result	Visualizasion
	Strain: - Very low to Low - Strain occur very low comparing with others.	

Table 4.3 FEA of Foot Supporter

Material	Result	Visualizasion
Alloy steel(Force 600 N)	Stress: - Low to Medium - Force mostly occur at the joint.	
	Displacement: - High to Very high - Movement absulutely occurs after putting in force espeacially at the end of the part.	
	Strain: - Low to Medium - Strain mostly occur at the joint.	

Material	Result	Visualizasion
Alumina (Force 600 N)	Stress: - Low to Medium - Force mostly occur at the joint.	
	Displacement: - High to Very high - Movement occurs after putting in force espeacially at the end of the part.	
	Strain: - Low to Medium - Strain mostly occur at the joint.	
Stainless Steel (Force 600 N)	Stress: - Low to Medium - Force mostly occur at the joint.	
	Displacement: - High to Very high - Movement occurs after putting in force espeacially at the end of the part.	

Material	Result	Visualizasion
	Strain: - Low to Medium - Strain mostly occur at the joint.	

CHAPTER 5
CONCLUSION, CONTRIBUTION AND RECOMMENDATION

5.1 Conclusion

As the elderly population continues to grow, there is a need for products that can support their daily activities. One such activity is grocery shopping, which can be a challenge for senior citizens. In this study, the product design and development method is applied to create a grocery shopping cart that can enhance the shopping experience for senior adults. The first step of the design process was to gather customer feedback through a survey to identify the problems and requirements of senior adults in grocery shopping. Based on the results, a new design was created by combining the existing product with functional components such as a smartphone holder, fan/cooler, lift-up plate, sensor, and light. To ensure the usefulness and quality of the new design, several calculations were performed using methods such as Quality Function Deployment and Bartlett's Test. The simulated force and material analysis indicated that HDPE and stainless steel were suitable materials for the container part (basket) and foot supporter, respectively. The outcome of this study can serve as a guideline for mass production of the designed grocery shopping cart for senior adults, which can enhance their quality of life by making grocery shopping a more comfortable and convenient experience.

5.2 Contribution and Recommendation

This study aims to develop a senior shopping cart that can support the daily activity of grocery shopping. The design process involved gathering customer feedback through a survey, as well as using engineering methods and comments from specialists to create a prototype of a new model. The new design was developed by following an existing product but still needs further study of ergonomics for more efficiency and comfort for the user. To ensure the usability and quality of the new design, several calculations were performed using methods such as Quality Function Deployment and Bartlett's Test. Additionally, Finite Element Analysis technique was applied to

determine the suitable material and force required during the use of the cart and calculate the maximum capacity of this model. The analysis results showed that HDPE and stainless steel are suitable materials for the container part (basket) and foot supporter, respectively. After creating a prototype of the new design, another survey will be proposed to gather feedback after users have had the opportunity to use the senior shopping cart. Based on this feedback, the design will be revised and developed until it meets the specific requirements and needs of senior adults in grocery shopping.

Key consideration: the outcome of this research can serve as a guideline for future mass production of the designed senior shopping cart, which can improve the quality of life for senior adults by providing a more comfortable and convenient grocery shopping experience.

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PHASE 2

PRODUCT FOR SUPPORTING “WORKING WOMEN”

CHAPTER 1
INTRODUCTION

1.1 Introduction

Over the past three years, the decision to pay less attention to going out and staying at home has been made by people during the COVID-19 pandemic, where online foods and products have become the choice and key tool for supporting their basic needs (Chen et al., 2023; Gössling et al., 2021; Rasoolimanesh et al., 2021; Rastegar et al., 2021; Rastegar, Seyfi, et al., 2021) However, not being comfortable with living like that as twenty-four-seven platform can be felt by some. Besides, worry, unease, or nervousness is being experienced by people more often due to the prolonged stay-at-home lifestyle in many parts of the country; typically, about an imminent event or something with an uncertain outcome. For instance, if people live in an area where nonessential travel is advised against, driving to an outdoor space would not be a good idea. The choice of outdoor activities is a great way to release these stresses and problems and get a change of environment. However, at this particular moment, on-and-off services in the middle of the coronavirus pandemic do not allow all outdoor activities to be performed as a full option/version. Some outdoor activities are not engaged right now; luckily, some are safe, which can help give people a much-needed mental reset. How to provide an easy-to-access product with durability plus flexibility where a "carry-on bag" is applied as the case study is proposed to support this activity.

Since "Quality of life" can be expressed as an individual's viewpoint of their place in life in respect to their current goals, expectations, standards, and worries, as well as the culture and value systems in which they live researchers have tried to provide specific concepts and approaches to enhance the quality of life of people in various fields; fundamental needs, logistics, medical services and facilities, traveling issues, automotive, and transportation (Hajiabadi et al., 2022; Parthasarathy & Vivekanandan, 2021; Srivastava et al., 2022b; Njoya, 2022) When the day-to-day of our lives is already super-stressful, finding ways for reducing stress by doing outside activities, where travelling and visiting nature can be greater decreases in stress than those who perform either indoors activities or who watch nature programming on visual

reality platform for the same amount of time, has been tried by people. From the obtained results, changing environment can make the mood of someone who is depressed improve more. These have led to the proposed approach of introducing an alternative design of a carry-on bag, which can support the users who would like to perform tasks while traveling where the conditions or the item(s) inside can be preserved as the original conditions.

1.2 Problem Statement

The provision of health-related products that are easy to access and use can be quite challenging as they are often expensive and difficult for target customers to obtain. This is primarily due to the limited availability of information and service providers who can provide detailed information on the pros and cons of these products, along with pictures and user guides. As a result, many customers resort to trial-and-error or blind-buying platforms, which can be time-consuming and frustrating due to the lack of information and support.

To address these challenges, it is essential to provide customers with products that feature universal design with minimal concepts, making it easy for customers to understand and use the product without extensive guidance. Customers can quickly assess the product and understand how to use it within a few seconds. Furthermore, customers must know where to purchase spare parts and have access to information on how to repair the product if necessary.

It is important to note that the design of these products must consider not only health-related concerns but also safety and trust, particularly for women. Women need products that provide protection and safety for their personal belongings while traveling or commuting to work, for example. A protective bag or container can help women carry their belongings with care, allowing them to work with ease and less concern.

By providing customers with products that feature universal design and minimal concepts, we can make it easier for customers to access health-related products, ultimately leading to improved health outcomes. Additionally, providing women with protective bags or containers can improve their safety and peace of mind while working or traveling.

1.3 Key Consideration of The Research

Discuss the benefits of outdoor activities: In addition to reducing stress, outdoor activities offer numerous health benefits such as improved physical fitness, reduced risk of chronic diseases, and increased Vitamin D intake.

Highlight the importance of travel: Traveling not only allows individuals to explore new places, but it also helps in broadening their perspectives, enhancing creativity, and providing opportunities for personal growth.

Emphasize the need for durable and flexible products: Products that are durable and flexible can help users travel with ease and reduce the risk of damage to their belongings. This can lead to a more enjoyable and stress-free travel experience.

Discuss the role of technology: Technology can play a vital role in supporting travel and outdoor activities, such as through the development of mobile applications that provide information on nearby activities or weather conditions.

Consider the impact of COVID-19 on the tourism industry: The pandemic has greatly impacted the tourism industry, leading to the closure of many businesses and the loss of jobs. It is important to explore ways in which the industry can recover and support the economic growth of the affected regions.

1.4 The Trends of Product of Interest

For the trends of product of interest – “the work and travel for women” and "carry-on bag" are two related topics that are gaining significant attention in recent times. As more and more women are entering the workforce and traveling for work, there is a growing demand for products that cater to their specific needs.

The work and travel trend for women refers to the increasing number of women who are traveling for business or work-related purposes. These women require products that are not only stylish but also functional and practical, allowing them to carry all of their essential items with ease.

One of the most important products in this category is the “*carry-on bag*”, which is designed to be lightweight and compact, while still providing enough space to carry all of the necessary items. The carry-on bag is also designed to be durable and flexible, making it suitable for use in a variety of settings and environments.

In recent years, the design and functionality of carry-on bags have evolved significantly. The focus is now on providing a combination of style and practicality, with features such as multiple compartments, expandable sections, and built-in charging ports becoming increasingly common. (Barnett, 2004; Fox, 1983; Gustafson, 2006; Sinclair, 1997; Woodell et. al., 2004) The trends of product of interest - the work and travel for women and carry-on bags - reflect the changing needs and lifestyles of modern women. As more women continue to enter the workforce and travel for work-related purposes, there is likely to be a continued demand for products that are specifically designed to meet their needs.

Moreover, the trend of the bag or baggage for supporting work and travel for women has seen significant changes over the years. Today's working women demand products that not only meet their functional needs but also reflect their sense of style and fashion. Thus, there is a growing need for bags that are both durable and fashionable (Chao & Schor, 1998; Manrique & Jensen, 1997; Shweta, et. al., 2016)

One popular trend in work and travel bags for women is the use of eco-friendly and sustainable materials. Consumers are becoming more environmentally conscious and are demanding products that align with their values. This has led to the rise of bags made from recycled or organic materials, such as recycled plastic, organic cotton, or hemp.

Another trend is the use of smart technology in bags. This includes features such as built-in charging ports for smartphones or tablets, GPS tracking, and anti-theft locks. These features provide added convenience and security for women on the go.

In terms of design, there is a growing trend towards minimalism and versatility. Many women prefer bags that can be worn in multiple ways, such as crossbody, shoulder bag, or backpack. This allows them to adapt to different situations, whether they are commuting to work or traveling. The trend towards customization and personalization is also gaining popularity. Many brands offer customization options, such as monogramming or choosing from a range of colors and materials. This allows women to create a bag that is unique to their style and preferences.

Finally, there is a trend towards affordability and accessibility. Many brands are now offering high-quality bags at lower price points, making them accessible to a wider range of consumers.

Key point: the trend of the bag or baggage for supporting work and travel for women is one that is constantly evolving to meet the needs and preferences of modern consumers.

1.5 Addressed Issues

Before delving into the five main stages of product design and development (PDD), it is important to address the issues related to the "carry-on bag" designed to support women's work-and-travel platform. The following are some key points to consider:

Trends in carry-on bag design: When designing a carry-on bag, the form, fit, and function details of the popular designs must be taken into account.

Hidden issues for women while carrying bags: The weight and number of items inside the bag are critical considerations. Each item has its own weight, which can have a direct effect on shoulder and back pain. The combined weight of all items (typically 10-20 items for women) can cause fatigue during extended periods of carrying, leading to indirect causes of office syndrome in the shoulder and neck.

Baggage or carry-on bag styles: The specific physical characteristics of the bag design should be carefully reviewed to ensure that they meet the needs of the target customer.

Load applied around the baggage when carrying items: To address this issue, designers can apply virtual reality simulations to determine the trend of forces (loads) on the area of interest. The results of these simulations can inform the concept development phase and help to redesign certain parts of the bag to meet safety criteria or prove whether the designer's assumptions are correct.

1.6 Scope And Limitation of The Proposed Research

The proposed design concept focuses on creating a bag that can support women's health and well-being during work and travel activities. To ensure that the bag

can be used as a carry-on for air travel, the design is limited to a small-scale platform that conforms to standard size requirements. The design concept was developed through a combination of digital-based questionnaires and direct interviews to gather insights and feedback from potential users. The engineering team then incorporated these insights into the design, identifying the main components and sub-components of the bag.

The ***main body of the bag*** is made of durable and strong materials such as polycarbonate (PC) and Acrylonitrile Butadiene Styrene (ABS) plastic. These materials were selected to ensure the bag can withstand wear and tear during travel and provide adequate protection for its contents.

To validate the design, ***Finite Element Analysis (FEA)*** was used to simulate the behavior of the bag under various loads and conditions. The analysis assumed that the objects inside the bag were fixed to each other, which established the contact conditions among them. In other words, the weight of the contents inside the bag was considered as a single unit to simplify the simulation and reduce testing time. The FEA analysis provided critical information that can serve as key guidelines for manufacturers or customers when selecting or designing a carry-on bag. The analysis revealed the critical areas of the bag that are subject to higher loads and are likely to break first. Manufacturers can use this information to improve the durability and strength of their products. Customers, on the other hand, can use this information to select a bag that can withstand the rigors of travel and provide adequate protection for their belongings.

Key point: the proposed design concept offers a new perspective on how traditional styles of bags or existing products can be improved to better support women's work and travel activities. By considering key factors such as durability, strength, and user experience, manufacturers can create bags that not only meet but exceed customer expectations.

CHAPTER 2
RESEARCH BACKGROUND

To uncover potential blind spots in business, gender should be considered as the most significant determinant that influences how individuals perceive the world around them. When it comes to product design and development, the gender of the target audience is especially important to consider. Gender is more powerful than factors such as age, income, ethnicity, or geography (Burke, 2023) In recent times, product design teams have recognized this and launched questionnaires to both men and women as their target customers, even for products that are traditionally marketed towards men, such as clothes, shoes, socks, shaving, or sportswear. This is because women play a crucial role as primary caregivers for children and the elderly in virtually every society worldwide. As a result, they often purchase products not only for themselves but also on behalf of the people who live in their households, as well as extended family members (such as older parents and in-laws) and friends. Therefore, women's purchasing power creates multiple markets in one, and their influence should not be underestimated.

2.1 The Status of Women in Society

According to data, there are 1.4 million more women with driver's licenses than men, and women are more likely to buy new cars than old ones. In actuality, women buy 62% of new cars in the whole country. (*Men Vs. Women: The Gender Divide of Car Buying*, n.d.-b) This significant influence on the automotive industry translates to a broader influence on consumer spending as well. Women influence 7 trillion dollars of spending annually and are responsible for 83% of all consumer spending (Catalyst, 2022) These numbers indicate a growing trend in the work-and-travel platform for women. As more women buy cars and spend more time traveling on the road, it is becoming increasingly important for entrepreneurs to create facilities or special items to support women's needs and make their travel experiences more enjoyable.

In Thailand, for example, traffic congestion in downtown areas means that people spend more time on the road, and minor activities such as working or reading

are common during these times. However, it is important to note that the national speed limit still applies during these periods of congestion. Therefore, it is crucial to consider daytime activities when designing products for the work-and-travel platform. This study proposes a drafted design of a product that takes these factors into account to support women in their work-and-travel activities.

2.2 Concerning Issue When Women Keep Stuffs in Bag

The target group of customers for this study are females aged 15-64 years, as they are the main consumers of the handbags market (Ltd, 2021) Women tend to express their preferences and needs more clearly than men, and they prioritize durability, reliability, safety, and affordability in their desired products. Men, on the other hand, are more drawn to features like interior layout, exterior styling, technology, and ruggedness (Macesich, 2015; Parkin, 2017) A cosmetic container is considered a basic need for women, and it should provide stability in room temperature to preserve sensitive items. This requirement is based on the perception that the container should provide some functions and space. Fig. 1 (Huang, 2020) illustrates an example of a cosmetic box available in the market that has many slots and functions, such as light-dimming brightness application attached to the mirror or compact size of the drawers. The style of this product is mainly based on the knowledge and skills to enable customers to feel relaxed and at ease, confident and assured that their expectations will be met or exceeded.

It is worth mentioning that the cosmetic industry is a lucrative market, and women are the primary consumers. According to a report by Allied Market Research, the size of the worldwide cosmetics market was estimated at $380 billion in 2019, and by 2027, it is anticipated to increase to $463.5 billion. (Stanton et. al., 2005) The growing demand for organic and natural cosmetic products is a trend that is gaining popularity among consumers. In addition, the emergence of social media and beauty influencers has created a significant impact on consumer behavior, and women are increasingly interested in trying new products to achieve their desired look. As such,

the design of cosmetic containers should consider the evolving needs and preferences of female consumers.

Figure 2.1. The Main Components of The Cosmetic Box (Huang, 2020)

However, in real-life situations, working women sometimes forget or accidentally leave their makeup sets in the wrong place, such as their car or in high-temperature environments, which can be a nightmare for them.

When comparing various types of cosmetic items that women need to own, “lipstick” is the winner in terms of availability, since it can be used anywhere, anytime, and by anyone. However, it is also reported that lipstick has the most sensitive structure and chemical properties compared to other cosmetic items (Laura, 2023; Mawazi et al.,2022; Pan & Germann, 2019; Ramos, 2016; Stanton et. al., 2005)

To support the design stage of this proposed study, the physical and chemical properties of lipstick were reviewed as the key component. It is assumed that if the lipstick can maintain its shape and properties under the conditions provided inside the developed carry-on bag, then other cosmetic products can also be preserved in their original conditions. This study aims to design a carry-on bag that can support work-and-travel activities while ensuring the preservation of cosmetic products, especially lipstick, under various conditions.

2.3 Key Factors to Make Customers Feel Comfortable

The design team has identified several key aspects of the carry-on bag design, such as the necessary compartments inside the bag, the materials used for making and covering the bag, and the bag's main structure. However, it is crucial to understand the customer's feelings and requirements in a more systematic way. Sometimes, customers do not want to answer long questionnaires or surveys as they perceive it as a waste of their time. To address this, the team has designed a self-administered survey, which is completed by the respondent without the help of an interviewer, to collect quantitative research data. Self-administered surveys come in different forms such as mail-in questionnaires, online surveys, and oral tests (Belisario et al., 2015)

Self-administered surveys are commonly used for collecting quantitative research data. Mail-in questionnaires and online questionnaires are two examples of self-administered surveys. Oral tests are another form of self-administered survey. However, with the rise of digital platforms and easy-to-access applications, there are some drawbacks to self-administered surveys. Distorted details and wrong instructions may be provided due to the "copy-and-paste" style of information sharing, creating new documents from unknown sources. Unscrupulous groups may even copy the identity of famous influencers to sell products to unsuspecting customers. These groups use personal information, pictures, and products of interest to create a false identity, and once they receive payment, they disappear and start again with a new name and persona on another platform. It is important to be cautious and verify the authenticity of any online platform or seller (Aghababaei & Makrehchi, 2016; Malleson & Andresen, 2015)

2.4 Reason And Factors Influence Women to Purchase

When it comes to purchasing decisions, women are often influenced by various reasons and factors. One of the most significant reasons is the need to feel confident and look good. Women purchase cosmetics and beauty products to enhance their appearance and boost their self-esteem. They also consider factors such as quality, brand reputation, and product ingredients before making a purchase.

Other factors that influence women's purchasing decisions include recommendations from friends and family, social media influence, advertisements, and promotions. Women tend to trust the opinions and experiences of people they know and often seek recommendations from them before making a purchase. Social media influencers and celebrities can also have a significant impact on women's purchasing decisions through product endorsements and reviews.

In addition to the above factors, convenience, availability, and price also play a role in women's purchasing decisions. Women often prefer to purchase products that are easily accessible, whether it be in-store or online, and at an affordable price point. They also consider the convenience of purchasing products, such as the ease of ordering online or the proximity of the store to their location.

In summary, the several factors that influence women's purchasing decisions are (Gusovsky, 2015; He et al., 2019; Milhorn, 2007):

- *Price:* Women tend to be price sensitive when making purchasing decisions. They look for products that offer good value for money and are affordable.
- *Quality:* Women also prioritize quality when making purchases. They prefer products that are durable and can be used for a long time without losing their effectiveness.
- *Brand:* Brand reputation is another important factor that influences women's purchasing decisions. Women tend to choose products from well-known brands that they trust and have a positive reputation in the market.
- *Convenience:* Convenience is a major factor that influences women's purchasing decisions. They prefer products that are easily accessible and can be purchased without much hassle.
- *Product features:* Women also consider the features and benefits of a product before making a purchase decision. They prefer products that offer multiple benefits and can serve multiple purposes.
- *Peer influence:* Peer influence also plays a role in women's purchasing decisions. They tend to seek recommendations from friends, family, and other influencers before making a purchase.

- *Emotional factors:* Emotional factors such as the feeling of indulgence, happiness, or comfort can also play a role in women's purchasing decisions. They may purchase products that make them feel good about themselves or boost their mood.

Key consideration: it is important for marketers to understand these factors and design their marketing strategies accordingly to appeal to women's preferences and needs. However, it is also important for women to be cautious and avoid purchasing products from illegal websites, as they may be unsafe and of poor quality.

2.4.1 Factor 1: Reliability, Empathy, and Trust

To ensure customer satisfaction, the design team and manufacturers must focus on meeting the needs and desires of their customers. The following statements provide key tools for supporting customer satisfaction (Gusovsky, 2015; He et al., 2019; Milhorn, 2007):

The priority is to take the time to find out what customers really need and want, which can be achieved by paying attention to facial expressions and other cues when asking questions. The design team can then show the customer how their needs and desires can be met, which engenders comfort, trust, and links to the reliability of the product and business.

Manufacturers must acknowledge and respect diversity, recognizing that women are a diverse group. In the 21st century, women are strong and independent, and they enjoy having their strength even after marriage and children. It is socially acceptable for women to pursue their own goals, whether that means working or furthering their education. Products targeting this group should provide durability, flexibility, and safety features.

A woman’s strength is very important to her and part of what self-confidence is built upon. Many women today are entrepreneurs/workers as well as mothers, wives, daughters, and sisters/aunts, among many other roles. Therefore, the products should provide durability, flexibility, and safety features to meet their needs.

Historically, women were not socially accepted in the ways that they are now, but they can now serve in any military branch, political office, or business capacity. Therefore, products should provide a “boyish” style that blends masculine and feminine

trends for a younger, more casual look. Alternatively, the “mannish” style is a masculine-focused fashion, featuring masculine and oversized items to accentuate femininity with masculine clothing for a more professional look.

In summary, understanding the background of the customers and respecting their roles or titles is crucial for creating a strong relationship. By doing so, manufacturers can maximize customer loyalty and create a bright future for their brand, service, or product.

2.4.2 Factor 2: Classic Requirements from Women Viewpoint

This section focuses on marketing and sales strategies for women consumers, including tips for understanding why women buy and what influences their purchasing decisions (Bakshi, 2012; Barletta, 2003; Green & Cunningham, 1975; Irigaray, 1997) The key points to keep in mind when marketing and selling to women are as follows:

- Women are regarded as the world's most influential consumers, and their influence on the economy is expanding every year. Companies need to pay attention to women's needs and preferences to stay competitive.
- Through a combination of their influence and purchasing power, women are responsible for about 70–80% of all consumer purchases. Even if a woman does not purchase a thing herself, woman frequently influences someone else to do so.
- Companies should avoid limiting themselves to the color pink when targeting female consumers. Offering a variety of colors and styles is important, as not all women like pink. Being versatile with flexible products can increase sales volume.
- Good customer service is a key tool for customer retention. Women tend to change their minds at critical moments, such as seeing bad service happen to other customers who are purchasing the same item from the same manufacturer or service provider. Manufacturers should strive to elevate the experience for women, which will benefit everyone who interacts with their business.
- Companies should avoid compromising on quality to offer lower prices. Consumers often fall for low prices and miss out on other important factors. If a collection of outfits is offered at a very low price, there is a chance that the quality will be degraded. Good things usually come at a good price.

- Women are getting married at older ages, and women (and men) are having fewer children than in previous generations. This means that women have more potential to buy something without being limited by financial stress.

In summary, understanding why women buy and what influences their purchasing decisions is essential for companies to create products and marketing strategies that appeal to female consumers. By offering a variety of colors and styles, providing excellent customer service, and maintaining high-quality products, companies can build customer loyalty and stay competitive in the market.

CHAPTER 3
RESEARCH CONCEPT

To create a successful product, it is important to consider the key factors of durability, flexibility, and accessibility. The process of product design and development (PDD) involves five main stages, which include concept development, system-level design, detailed design, testing and refinement, and production ramp-up. Figure 3.1 shows the flowchart of these stages in the PDD process.

During the *concept development stage*, the initial idea of the product is generated, and the product's main features and functions are determined. This stage is crucial in determining the feasibility and potential success of the product.

In the *system-level design stage*, the product's subsystems and components are defined, and their interrelationships are established. This stage helps to ensure that the product is designed to meet its intended purpose and functionality.

In the *detailed design stage*, the specific details of the product are developed, including the dimensions, materials, and manufacturing processes. This stage is critical in ensuring that the product can be manufactured efficiently and cost-effectively.

The *testing and refinement stage* involves prototyping and testing the product to ensure that it meets the required standards and functions correctly. This stage helps to identify any potential issues and allows for necessary modifications to be made.

Finally, in the *production ramp-up stage*, the product is prepared for mass production and launched into the market. This stage involves optimizing the production process and ensuring that the product meets quality and safety standards.

Key point: the PDD process is a critical aspect of developing a successful product, and careful consideration must be given to each stage to ensure that the final product is durable, flexible, and accessible.

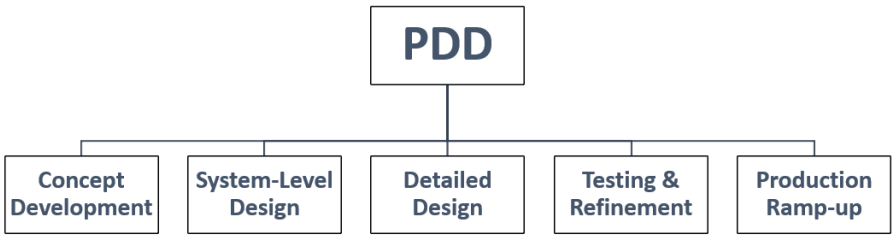


Figure 3.1 Five phases of PDD for creating a new product.

3.1 Concept Development Stage

The combination of a waterproof cooler food storage and a briefcase-design platform is being used as a reference model to support the design team in creating a drafted model of a carry-on bag. The aim is to achieve a small-sized bag with the features of both a thermo-bag style and a briefcase-design platform. The concept of "3Fs - Form, Fit, and Function" is applied in order to create a drafted design of a new bag. The design team identifies the ideas and the direction for creating the carry-on bag. To determine the proper number of respondents who will be the target customers, the classic method of sample size analysis is being discussed. This will help in determining the sample size needed to get an accurate representation of the target market's opinions and preferences. Figure 3.2 shows a waterproof-cooler food storage designed in a thermo-bag style, which includes insulated pouch accessories. This type of bag is specifically designed to support outdoor activities by keeping food and drinks cool and fresh. The insulated pouches can also be used to store other items such as utensils or electronic device (Peter, 2021)

Figure 3.2 Waterproof-cooler food storage (thermo-bag style) for supporting outdoor activity with insulated pouch accessories item (Peter, 2021)

Figure 3.3 Small compact 4 wheeled briefcase with 3.231-kg weight (*Wheeled Briefcase - Rolling Luggage, Bag with Wheels | TUMI HK*, n.d.)

3.1.1 Form/Fit/Function – Guideline for A New Design

Form is an essential aspect of product design that refers to the physical appearance and characteristics of the product. The design team can extract main components and reference existing products available in the market to support their design process.

For the waterproof-cooler food storage depicted in Figure 3.3, the main body's outer surface is made of EVA material and oxford cloth to provide waterproofing, lightweight, and stylish appearance. However, the cushion material is not included in this bag, and it may not be suitable for carrying digital devices or tablets.

For the small compact 4-wheeled briefcase, it provides a design and function that is suitable for work-and-travel platforms, as it can properly support digital gadgets and devices compared to the previous design. However, the weight of the 4-wheeled briefcase made from polycarbonate and polyester materials might be a concern for some users, especially women.

In addition, for travel via airlines, the size of the bag is a significant consideration. The allowable carry-on baggage size can vary according to the airline and cabin class customers are traveling in, as well as the size of the aircraft. The general rule is that carry-on baggage should have a maximum length of 22 in (56 cm), a width of 18 in (45 cm), and a depth of 10 in (25 cm) (McDarris & Geller, 2023) Figure 3.4 shows examples of baggage restrictions announced by airlines (*British Airways 2023 Baggage Allowance | My Baggage*, 2023) On board, each passenger is allowed to bring

one piece of hand luggage and one small item (handbag/laptop). Small items must not be more than 40cm x 30cm x 15cm and hand luggage must be larger than 56cm x 45cm x 25cm. Each item can be up to 23 kg in weight.

Customers need to be aware of these restrictions to avoid paying fees. If the customer's hand luggage weighs more than the allowed amount, it will be checked into the hold and added to their allowed amount of checked baggage. Customers will be charged the airport's excess baggage fees if it goes over this limit. (*British Airways 2023 Baggage Allowance | My Baggage*, 2023)

Figure 3.4 Baggage restrictions (*British Airways 2023 Baggage Allowance | My Baggage*, 2023)

3.1.2 Sample Size Analysis

A sample size represents the number of completed responses a survey receives and is a subset of the target population. This research focuses on work-and-travel supportive bags and aims to identify the most significant concerns of women regarding their favorite activities using a statistically significant sample size (Morse, 2000) However, customer perceptions and behaviors from experiences may lead to biased responses, which are beliefs not initiated by known facts about someone or a particular group (Zeithaml et al., 1990) Satisfaction levels of women's favorite activities can be expressed through facial emotions or tone of conversation. Still, online questionnaire

platforms have become a popular tool, and total time spent on the questionnaire is also taken into account as a measure of willingness and concentration to complete the assigned task. Respondents submitting the questionnaire too quickly or slowly may indicate a lack of concentration or consciousness to perform the task, which is a function of mind, understanding, emotions, instinct, and memory. Providing concise, 5 to 7 sentences "storytelling" of the carry-on bag to inform target customers before answering questionnaires can help focus their intellect and override their emotions, leading to more focused responses. Basic demographic variables such as age, culture, place of residence, educational background, occupation, and salary are included in the surveys (Jaeger, et. al., 2013)

The study examines the perceptions and behaviors of people living in the Bangkok metropolitan region through survey questions designed to assess how they feel about their favorite activities. As the researchers had limited information on the subject, they assumed that half of the respondents would decide to travel and bring assigned tasks to complete. This assumption provided maximum variability, and Equation (3.1) was applied (Iacobucci, 2010; Israel, 1992)

$$\left(\frac{(Z)^2 \; x \; p \; x \; q}{(e)^2}\right) = n, \qquad (3.1)$$

where

e is the desired level of precision (the margin of error, or confidence interval)

p is the estimated proportion of the population that has the attribute in question

q is 1 – p.

A margin of error of 5%. The sample size required for this study was calculated using Equation (3.1), where n = (Z^2 * p * q) / e^2, where n is the sample size, Z is the Z value, p is the estimated proportion of the population that has the attribute of interest, q is the complement of p (i.e., 1-p), and e is the desired level of precision.

Assuming p = 0.5 and e = 0.05, the required sample size for this study is:

$$\left(\frac{(1.96)^2 \; x \; 0.5 \; x \; 0.5}{(0.05)^2}\right) = 385, \qquad (3.2)$$

Therefore, a sample size of at least 385 is needed to achieve a 95% confidence level with a margin of error of 5%.

Based on the calculated value, it was determined that a random sample of 385 respondents from the target population was sufficient to achieve the required confidence levels. Around 500 online questionnaires were distributed to the target customers, and 400 respondents returned their completed questionnaires during the initial concept development phase. The collected data were used to create a conceptual model of the carry-on bag, which was then translated into a 3D CAD model. The monthly income and favorite activity of the target customers were the key factors considered in selecting the appropriate materials for creating a carry-on bag, as presented in Tables 3.1 and 3.2. The findings revealed that the first and second groups of monthly income were the major target customer groups, with a salary range of around 35,000 – 100,000 THB (1058.14 - 3023.16 USD). This suggests that they could benefit from the work-and-travel platform with less stress compared to the average salary in Thailand, which is 24,500 THB (734 USD) (Sully & Sully, 2023)

Table 3.1 Monthly Income of The Respondents

Monthly Salary		**No. of Respondents (400)**	**(%)**
(THB)	**(USD*)**		
< 15,000	453.47	36	9
15,001 – 25,000	453.50 – 755.79	56	14
25,001 – 35,000	755.82 – 1058.11	68	17
35,001 – 50,000	1058.14 – 1511.58	108	27
50,001 – 100,000	1511.61 – 3023.16	104	26
> 100,000	> 3023.16	28	7

* Foreign Exchange Rates as of 19 January 2023 – Exchange Rate = 33.078 THB/US Dollar

Table 3.2 displays the favorite activities of women when they have free time, with the top four being *Traditional Shopping, Travelling, Communication with Family & Friends,* and *Outdoor Exercise*. These findings provide valuable insights for the design team in terms of the direction they should take when developing the supportive

work-and-travel bag. Specifically, the fact that "Traveling" is one of the top activities indicates that the bag should be designed with the needs of travelers in mind, such as having enough space for essentials, being easy to carry, and durable enough to withstand the rigors of travel. In addition, the other activities listed, such as Traditional Shopping and Outdoor Exercise, suggest that the bag should also be versatile enough to accommodate different types of activities and lifestyles. By taking these factors into account, the design team can create a bag that meets the needs and preferences of the target customers.

Table 3.2 Monthly Activities of The Respondents

Favorite Activities	**No. of Respondents (400)**	**(%)**
Traditional Shopping	67	16.75
Travelling	63	15.75
Communication with Family & Friends	59	14.75
Outdoor Exercise	46	11.5
Cooking	43	10
Housecleaning	40	10
Online Shopping	23	5.75
Religious Activities	16	4
Indoor Exercise	15	3.75
Singing	13	3.25
Embroidery	6	1.5
Gardening/Planting	4	1
Language Learning	2	0.5
Musical Activities	1	0.25
Watching TV/Movies	1	0.25
Working	1	0.25
Art Activities	0	0

The study considered two alternative design concepts as shown in Figure 3.5 and Figure 3.6, which are suitable for carrying different types of items and are popular as everyday bags for women.

Design A (Figure 3.5) features waterproof-insulated material and a gusset on the bottom area with a trapezoidal prism-shaped design for the main body.

Design B (Figure 3.6) provides a solid structure of the main frame, similar to a briefcase or hand baggage style with a small size. However, the fixed finger grooves

structure of the handle might not be comfortable for all users, as the space between a concave-up (curve) is not a universal design that fits all sizes of fingers and hands. Therefore, it would be better to provide a straight-line handle design as a universal design concept that supports various scales of palms, hands, and fingers.

Design C (Figure 3.7 to 3.9) is the original design of a carry-on bag that provides a solid structure of the main frame, similar to Design B. For the handle, it is recommended to use a straight-line or arched trunk handle similar to a briefcase bag, which illustrates the universal design concept and supports various scales of palms, hands, and fingers.

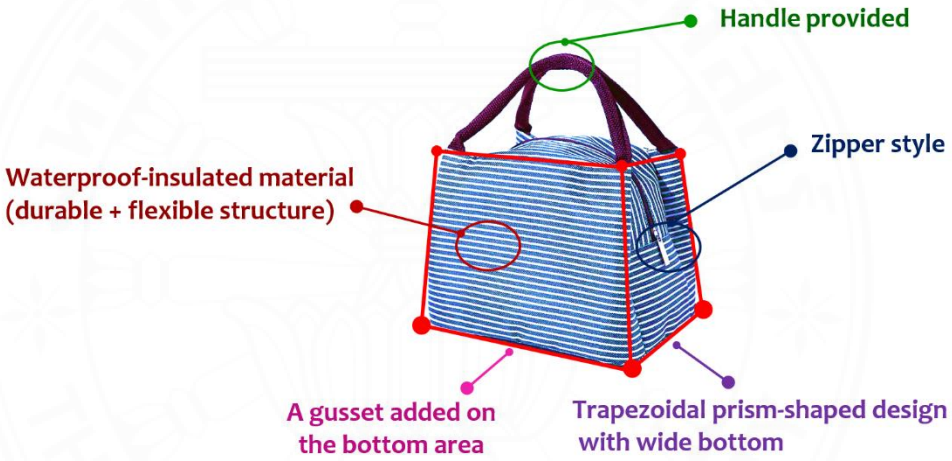


Figure 3.5 Main Components of The Carry-On Bag – Design A.

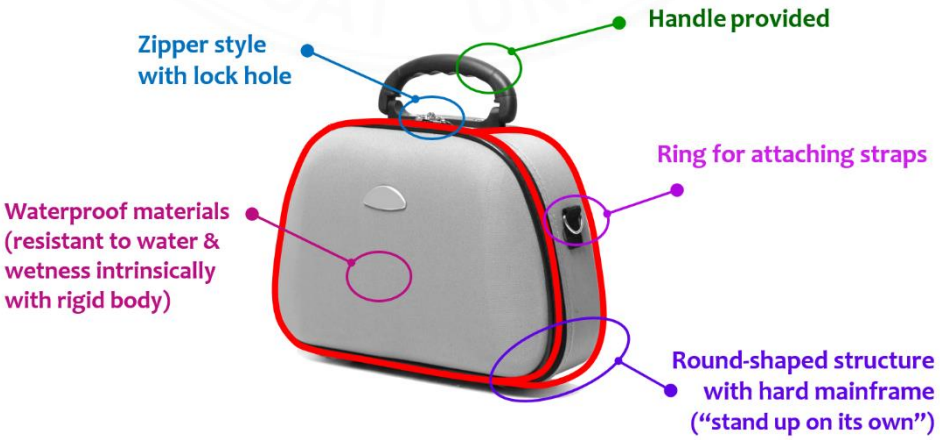


Figure 3.6 Main Components of The Carry-On Bag – Design B.

Figure 3.7 Original Design Of "Design C" – Carry-On Bag Inspired from Classic Briefcase Baggage – Design B, (Left) Isometric View, (Right) Transparent Display of Isometric View.

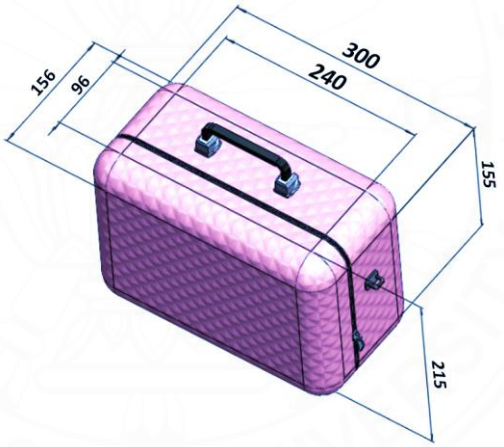


Figure 3.8 Original Design Of "Design C" – Isometric View with Dimension.

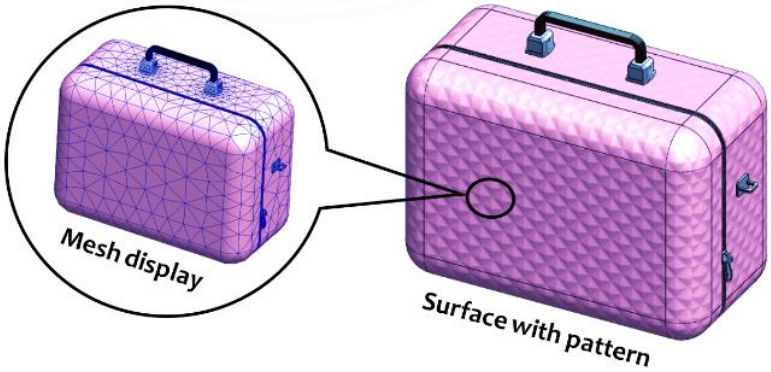


Figure 3.9 Design C –Printed Pattern Provided on The Body's Surface: Mesh Model Showing Smooth Surface Without Texture.

In 2021, S. Rianmora and S. Seng introduced the "Keep It Cool" Smart Bag with an alternative design that utilizes the Internet of Things (IoT) for better living (Fig. 11). The key concept of this design is to provide a "smart bag" that can support users in keeping their sensitive cosmetic products in good condition while travelling to another location where temperature control is important. The bag allows users to easily adjust and control the temperature and humidity conditions inside the bag through a smartphone application. Unlike traditional insulated bags, this smart bag will not damage or destroy the physical or chemical properties of the products. The research emphasizes that the IoT technology can make life easier with simple and convenient functions applied with less effort and investment cost.

Figure 3.10 “Smart Bag” Prototype Propsed by S. Rainmora, And S. Seng (Rianmora, S & Seng, 2021)

Based on the key points mentioned earlier, such as a solid-profile structure resembling a briefcase bag, a minimal handle design, a zipper closure platform, and an air ventilation unit with a small fan for preserving the original condition of items inside the bag, the proposed design (Design D) incorporates these elements to create the conceptual model depicted in Figures 12 and 13. An optional function of air ventilation with an automatic fan unit has been added to the original briefcase-like platform of Design C.

Figure 3.11 Main Components of The Carry-On Bag – Design D, (Left) Isometric View, (Right) Transparent Display Of Isometric View.

However, the issue of load distribution and weight of the bag and its contents have not been thoroughly addressed in recent research by S. Rainmora and S. Seng (2021). This presents an opportunity to further investigate and optimize the mainframe design of the briefcase-like bag to ensure optimal load-bearing capabilities. Therefore, the proposed research aims to study and develop a briefcase-like bag with an air ventilation unit (i.e., a small fan attached to the frontal area of the bag) using Finite Element Analysis (FEA), which will be discussed in detail in *Section D – Testing and Refinement Stage.*

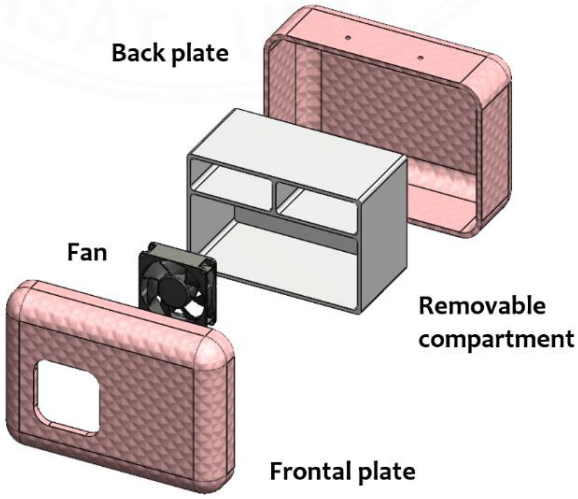


Figure 3.12 Revealing the Body Components Of The Carry-On Bag – Design D.

3.2 System-Level Design Stage

This sub-section is required for classifying the carry-on bag of Design D into main components and sub-components. In general, there are many components to a bag depending on the style and configuration. In general, there are three key elements that apply to most bags, which are body and compartment, closure and opening, and strap and handle.

For ***Design D***, the main components can be classified as follows:

1. Body and Compartment:

Main frame/body: this is the primary structure of the bag, which determines its shape and size.

Front and back panel: these are the panels that make up the front and back sides of the bag.

Bottom gusset: this is the area at the bottom of the bag that provides extra space and support.

Air ventilation unit: this is the component that allows for the circulation of air inside the bag, helping to maintain the condition of the items stored inside.

2. Closure and Opening:

Zipper closure: this is the mechanism that allows the bag to be opened and closed.

Zipper pulls: these are the components that are used to operate the zipper closure.

3. Strap and Handle:

Shoulder strap: this is the component that allows the bag to be carried over the shoulder.

Handle: this is the component that allows the bag to be carried by hand. In Design D, the handle is a straight-line design for universal support.

In addition to these main components, there may be sub-components such as pockets, compartments, and internal dividers, depending on the specific design of the

bag. The details of each main component will be mentioned and discussed in the following sub-sections.

3.2.1 Body And Compartment

The body of Design D is designed to have a size of 40 x 30 x 15 cm, with a zipper or other easy-to-access style for convenient access to the items inside. The bag is secured with a clasp locker, a commonly used device for binding together two edges of fabric or other flexible materials. A gusset can be added to the bag to strengthen its structure and reinforce key points. Feet on the flat bottom can also be added to protect the bag when it is placed on the ground.

When choosing the materials for the bag, both function and style should be taken into consideration. For instance, if the bag is meant to hold a computer, it might not be round in shape. However, bags with unique shapes can be great ways to express the designer's style. The bottom of the bag can have a boxed bottom with studs or feet or have a gusset on the bottom and sides to hold more items and stand up on its own.

For **Design D**, waterproof-like fabric or polymer is recommended for the materials used in this area. Some high-tech plastics such as polyethylene, ABS, and polycarbonate are lightweight and durable, making them suitable for supporting work-and-travel platforms. ABS is lighter, but polycarbonate is more durable, and aluminum is the most durable but also the heaviest material. The interior and exterior pockets can be added to the bag for additional functionality and to change its look.

3.2.2 Closure And Opening

The opening of a bag is crucial since it serves the important function of securing belongings and can make access easier or harder depending on customer needs. Additionally, the design and pattern of the opening can have a direct effect on the physical appearance of the bag. While there are many options for bag closures such as drawstrings, carpet bag hardware, snaps, magnets, turnbuckles, or zippers, the latter is often preferred for its ease of use and accessibility by users. However, zippers may fail due to broken or misaligned teeth, slipped stitching, or broken or warped heads and pull

tabs, and their quality can be indicative of the overall quality of the bag. YKK zippers are widely considered to be the most reliable on the market.

In this study, the concept of easy access while keeping items securely inside the bag is prioritized. For this purpose, traditional zipper styles are recommended, particularly when a locking function is required. Zippers come in two types: chain and coil. A chain zipper consists of two sets of interlocking metal teeth, making it stronger and more durable than a coil zipper, which slides on two parallel coils typically made of polyester. The key benefit of chain zippers is their resistance to break-ins compared to coil zippers, which can be easily pulled apart with a ballpoint pen and then reclosed.

3.2.3 Strap And Handle

This element of a bag is crucial as it determines how users will carry the handbag and how much weight they can comfortably carry. The strap/handle makes contact with the body and supports the weight of the bag and its contents. The load can be carried in the hand, over one shoulder, across the body, or around the waist. The following specific characteristics of straps and handles are key considerations:

1. *Strap width:* Wider straps can distribute larger loads better than narrower ones of the same material and pattern. The width of the strap depends on the size of the bag and the weight of the contents. For smaller bags, narrow and delicate straps can still be comfortable and supportive.

2. *Strap length:* The length of the strap is primarily dictated by function and style. Adjustable padded shoulder straps with swivel snap hooks offer convenience and flexibility. Removable straps can be attached in different ways, allowing for versatility. Fixed straps, mounted directly into the handbag, offer added security and can be a striking design feature, but need to be sized correctly.

Guidelines for material types for straps imply the strength and comfort of the bag. Leather or webbing is strong enough to be used as a single layer strap with high stiffness value, while some textiles need to be doubled (or more) over and stitched for added strength.

For *handles*, they are often the main way to carry a small handbag and can be a striking design element when made from contrasting materials.

In order to support the detailed design stage, the researchers have assigned the main components of a bag, including body, closure/open, and handle, to help quickly assign specific characteristics to the new design of a carry-on bag without trial-and-error.

For the carry-on bag design, the body is trapezoidal-prism shaped with a pyramid-like platform and round-corner design, and a wide bottom. The bag has a removable compartment for flexibility and is made of waterproof material that allows the bag to stand on its own without gusset. The closure/open is a chain zipper type with a ring for attaching straps. The handle is a round-and-thick style with an ergonomic curve.

In summary, the main frame and function of a carry-on bag are constructed according to "Design D," with three key elements of body, closure/open, and handle, each with specific considerations and guidelines to ensure a functional and stylish design.

3.3 Detailed Design Stage

In order to design a bag product suitable for carrying items, there are key considerations that need to be addressed. The first consideration is to identify the common items that women carry in their bags. Easy-to-access online resources were utilized to compile a list of 31 popular items carried by women (Table 3.3). However, carrying these items can cause pain in the forearm and shoulder due to the weight of the bag and its contents.

To identify the force applied to the bag during everyday use, researchers have attempted to identify key factors that directly affect the bag. One of these factors is the weight of the items inside the bag. After identifying the handbag essentials that modern women carry, it was found that the total weight of the bag and its contents is around 3,200 g (or 3.2 kg). This suggests that women must carry the load of both the bag itself (200-500 g) and its contents.

FEA results obtained from SolidWorks application were used to determine the areas affected by load distribution, which include the front and back areas as well as the handle portion (Table V).

Design A is a folding tote bag made from waterproof-insulated material with a water-resistant bottom, weighing approximately 99-115 g.

Design B is a solid bag with zippers and a finger-grooved handle, resembling a small briefcase and weighing around 1 kg.

Design D (Figure 3.11) contains a main body, removable compartments for interior design, a universal straight-line handle, and a strap. Additionally, air-ventilation with a small fan was applied according to the controlling system proposed by S. Rianmora and S. Seng (2021). The body components of **Design D** are illustrated in Figure 3.13, and this model will be used in FEA simulations to study the force/load distribution applied around the front, back, top, and bottom areas of the bag.

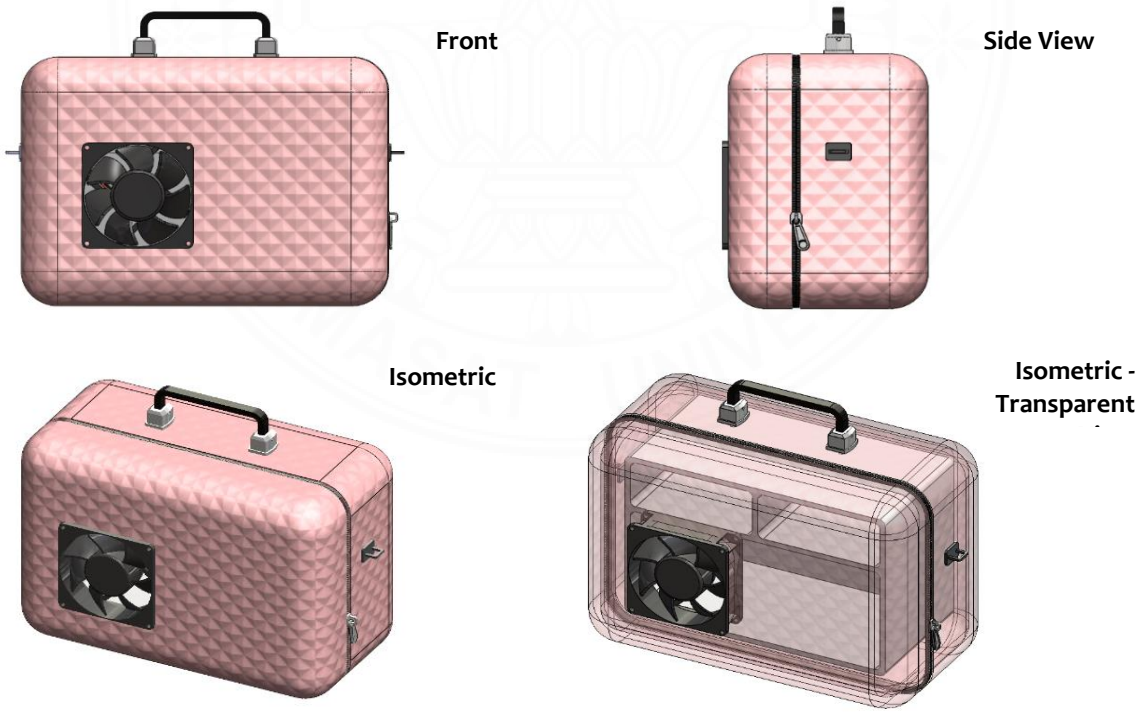


Figure 3.13 Four Views of The Carry-On Bag – Design D.

3.4 Testing And Refinement Stage

To minimize the risk of shoulder and arm pain caused by carrying loads every day, the researchers have studied the effect of loads from the bag itself and the items carried inside. In order to do this, they extracted the weight of each item and combined them to create a reference for load contribution activity, which involved testing and refinement using the Finite Element Analysis (FEA) method. This was done to study the impact force, which is a force that delivers a shock or high impact in a short period of time and is caused by objects falling onto or slamming into the bag. The FEA method was chosen as it allows for the determination of the amount of external force applied to the bag, which is crucial for designing a bag that can withstand such impacts. The results of this study were used to design bags that are both functional and comfortable to carry, while minimizing the risk of injury.

In order to simulate the behavior of the carry-on bag, several key components must be considered, including the type of material used for each element of the bag, the direction of the applied load, and the type of motion applied. The simulation settings remain the same, except for the fixed geometry, force, and mesh size, which will vary based on the area of interest. Table IV provides a breakdown of the materials used for each component of the carry-on bag, which were chosen based on the expertise of the design team and industry professionals. For each material, the Young's modulus (E) value was determined. Young's modulus is a material property that describes how easily it can stretch and deform under stress and is defined as the ratio of tensile stress (σ) to tensile strain (ε). Stress is the amount of force applied per unit area ($\sigma = F/A$), and strain is the extension per unit length ($\varepsilon = dl/l$) (Segerlind, 1976; SOLIDWORKS, 2016)

In order to conduct Finite Element Analysis (FEA), the simulation with commands was performed in the SOLIDWORKS program to identify the von Mises stress of each area. Four areas of interest were studied (as shown in Table V) and the static/stress was selected to calculate displacements, reaction forces, stresses, strains, and factors of safety distribution of the model. The simulation process can be performed by following these steps: **Part > Connections > Fixture > External Load > Mesh > Run.**

Table 3.3 Handbag Essentials Every Modern Woman Carry in Her Purse

No.	Item	Weight (Unit in "g")	Source
1	Battery case or portable cellphone charger/ Portable Charger	125 – 620	(Gilmore, 2023)
2	Tablet	460 - 470	(Walloga, 2016)
3	Earphones or air pods	38.3	(Apple, n.d.)
4	Diary / notebook / notepad	190	(Cpt, 2021)
5	Mobile phone	130 – 200	(Cohen, 2022)
6	Nail file	13	(Weigher, 2019)
7	Wallet (Leather)	28.35 – 85.05	(Concord, 2023)
8	Hand cream (100 mL)	86 – 90	(Weigher, 2020)
9	Hand sanitizer	190	(PureHands Hand Sanitizer, n.d.)
10	Mask (Extra Masks)	12.5 g/pc	(Sangkham, 2020)
11	Lipsticks, lip gloss, or lip balm	2.5 – 4.3 (Avg. 3.4)	(*Do You Really Eat Fo Pounds of Lipstick in Your Lifetime?* n.d.)
12	Sunscreen (88 ml)	85.05	(*Neutrogena*, n.d.)
13	Face moisturizer (50 mL)	96.4	(Sunscreen and SPF Moisturizers | Skincare CeraVe, n.d.)
14	Handkerchief/Tissues: wet wipes (small pack – 25 wipes)	160	(*Hand and Face Wipes* n.d.)
15	A period (a sanitary) pad	4.7 – 14.1	(Sasidaran et al., 2021
16	Zippered pouches	40.5	(IDEAL® Pro Series Flat Zipper Pouch, 4-Pack, n.d.)
17	Reusable Bag (HDPE)	5.5 g/pc	(Leeuwen, 2013)
18	Breath freshener/ Mint or any chewing gum	240	(Hugs, 2023)
19	Aromatherapy pulse point oil/ Travel-size perfume bottle (88 mL)/ Deodorant	85.05	(Vital Luxury, 2023)
20	Hair stuff: hair brush, scrunchies, rubber bands, hair bands, clips, or clutches	5 – 8	(Walgreens, 2023)
21	Sleek compact mirror – (48 x 48 x 6 inches)	109	(VrHere MirriM, 2023
22	Makeup Kit (travel-sized set)	80	(Beauty, Dream Life, 2017)
23	A Pen (1 g[69]) & Paper (one A4 paper – 5 g[70])	6	(Inkbeta, 2022; Munk, 2020)
24	Medication	0.5 – 2.4 g/pc	(Otsuka et al., 2007)

No.	Item	Weight (Unit in "g")	Source
	Blister packs (10 pills/pack) (unit-dose packaging for pharmaceutical tablets)	3 g/10 pills/pack (0.3 g/dose)	(Sean, 2022)
25	Plasters (50 g – 60 pcs.)	0.83 g/pc	(Band Aid, 2023)
26	Sunglasses or Reading glasses (40 g[74]) and its case (47 g[75])	87 – 90	(Band Aid, 2023; Koalaeye, 2021)
27	Business cards / Card holder	30	(Generic, 2023)
28	A Key	7	(Velyrhorde, 2022)
29	Safety pins	0.1 g/pc	(Faroutguides, 2023)
30	Foldable umbrella	120	(MUJI, 2022)
31	Candy/ Chocolates/ Snack Bar	28	(Milk Chocolate Nougat Bar, 2023)

Table 3.4 Type of Material Required Making Each Element Of A Carry-On Bag

No.	Part	Material	Young's Modulus (MPa)*
1	Outer Shell	ABS PC	2410
2	Carry Strap	ABS PC	2410
3	Carry Strap Hook	Aluminum 1060 Alloy	69000
4	Side-Hook	Stainless Steel	200000
5	Interior Compartment	Low Density Polyethylene (LDPE)	172
6	Strap	Rubber	6.1
7	Swivel Strap Hook	Stainless Steel	200000

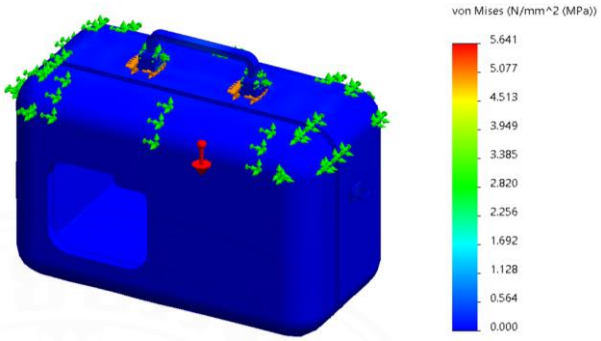
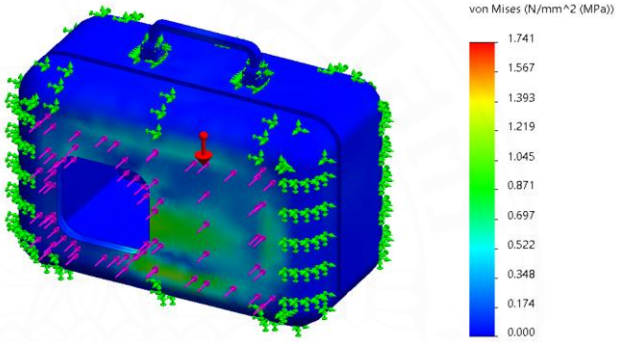
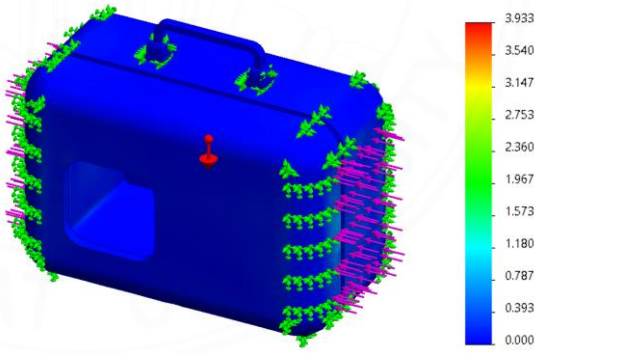
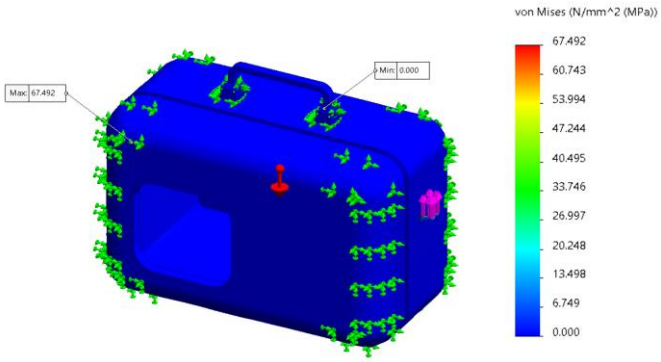
Source: * Young's Modulus of each material is the default value provided in SolidWorks (Hughes, 1987)

For each area of interest, the simulation was carried out by applying an external load of 1000 N to the carry strap and to the front, back, left, and right sides of the model. The proper material for each part of the bag was first set in the "Part Property Manager", followed by the "Connections Property Manager" to specify the interaction conditions that control the action of the selected components during simulation. The "Fixture Property Manager" was then used to define displacements on vertices, edges, or faces of the model. In the "External Loads Property Manager", the Distributed Mess, Gravity, and Force commands were used to assign the distributed mass, gravity force, and force for each area of interest. The blended curvature-based mesh was used in the Mesh application with a mesh size of 35 mm.

The simulation results showed that the maximum von Mises stress occurred on the strap was 5.641 MPa, while the maximum von Mises stress in the front and back sides of the outer shell was 1.741 MPa, and in the left and right side of the outer shell was 3.933 MPa. In conclusion, the maximum von Mises stress did not exceed the yield strength or Young's modulus of the PC/ABS material used for the three areas, which means that these areas will not break with the load of 100 kg or 1000 N. As for the side hook, the maximum von Mises stress occurred at around 67.492 MPa, which did not exceed the yield strength or Young's modulus of the stainless steel material used, indicating that this area will not break with a load of 10 kg or 100 N.

It is worth noting that the time spent for simulation depends on the mesh size, number of areas of interest, and size of the virtual model, with a range of around 30 minutes to 1 hour for each simulating process in this study.

Table 3.5 FEA Simulation On "Design-D" Of the Proposed Design

Area of Interest	External Force (N)	Max von Mises (MPA)	Result
Handle	1000	5.641	
Front and back sides of the outer shell	1000	1.741	
Left and right sides of the outer shell	1000	3.933	
Side hook	100	67.492	

3.5 Production Ramp-Up Stage

To support the platform of start-up companies as they transition from the prototype stage to regular production, ramp-up is necessary to bring the company's capacity utilization close to maximum. The key concept during this stage is to ensure that the right person is in the right place at the right time. Ramp-up occurs during the execution stage when additional resources are needed to complete different tasks. The resource manager identifies and allocates appropriate resources to fulfill resource requests.

In this study, guidelines for designing a 3D virtual model of a carry-on bag are provided, including details about the body structure, handle, and closure functions. An easy-to-maintain function is suggested, such as applying a waterproof-polymer surface cover to make water or rain roll off the surface immediately. Safety conditions relating to force (load) distribution on the bag during carrying and traveling are also considered.

To support the two stages of PDD, namely concept development and production ramp-up, the calculation about the usefulness of products is used. This method is applied to identify and select a suitable design from two or more alternative designs during the concept development stage. During the production ramp-up stage, the decision made by the design team is rechecked and verified to ensure that it is correct and follows a good pattern of design stage. The usefulness of products approach can be used to decide which product component(s) should be taken into account, chosen, and updated before being utilized as the reference(s) for a new design and development.

However, in this research, a physical prototype has not been created yet. Only graphical shapes via artworks and 3D CAD models are used, and the alternative designs are considered to use as the reference prototype. The design team must make a decision on which one is the best or the most suitable one. Applying the usefulness of products method can help identify which component(s) of the product(s) should be considered and selected for modification.

To apply the usefulness of products method, the concept of "needs" by Maslow's Hierarchy of Needs is used to support the design team in selecting suitable values. However, making decisions as a group can be suggestive. Potential members with skilled or experienced backgrounds in the product are required to suggest and discuss

the issue in a systematic way. In this study, bags or containers used for storing stuff are considered as basic and safety needs according to Fig.15. Thus, from the importance level (Table VI), bags can be considered as "Very High" level where the main benefits can be implied about supporting essential for daily activities and compulsory daily activities.

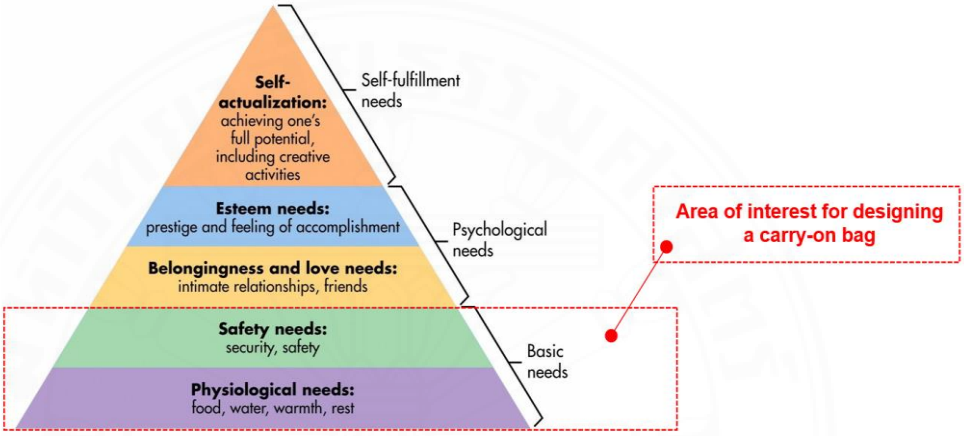


Figure 3.14 Maslow's Hierarchy of Needs (McLeod, 2007)

The key components of “usefulness of products” can be expressed as:

3.5.1 Important Level

The concept of "importance of use" refers to the extent to which a product affects the lives of its users. The higher the impact a product has on society, the greater its value of usefulness. The degree of importance of a product depends on the extent to which it affects the life of its users. While some items are essential for human life, others may not be as critical. To facilitate evaluation, five levels of importance of use have been identified and are presented in Table 3.6.

Table 3.6 Level of Importance Of Products (McLeod, 2007)

Code	Points in a scale of 5	Level of importance	Type of importance	Product examples
A	5 (>4.0 - 5.0)	Extreme	• Life-saving drugs, life support systems • Patient life support system • Medical equipment, medicine	Mechanical Ventilator or Equipment, Defibrillator, Heart/Lung Bypass Machine (Oxygen Cylinder, Pacemakers)
B	4 (>3.0 - 4.0)	Very high	• Essential for daily activities • Compulsory daily activities	Water, Taking Food, Using Restroom, Vehicles, Bags or Containers to carry stuffs safely
C	3 (>2.0 - 3.0)	High	• Accommodation • Social communication • Banking transactions	House, Clothes, Internet, Computer, Smartphone, EDC Machine, Pen, Belt, Spectacles, Shoes
D	2 (>1.0 - 2.0)	Medium	• Household appliances • Machines for daily needs	Air-conditioning system, refrigerator, washing machine
E	1 (0.0 - 1.0)	Low	• Recreation activities • Entertainment systems • Recreation systems	Television, Comics, Books, Computer games, Bowling, Go-carting

From Table VI, it is evident that the level of importance of products can be modified and adapted based on the current situation and conditions required by people living in society at that period. New technologies have the potential to change and elevate human condition, improving the quality and standard of life. The importance of products can be modified by considering how technology or invention applied for creating some products becomes more important and necessary for living compared to the results or performance of itself in the past, which is referred to as a "high level." For instance, the availability of internet banking transactions has significantly impacted the way people conduct financial transactions. In the past, banking transactions could only be done and executed at the local branch service area of the bank. Nowadays, customers can perform banking transactions such as transferring money, paying bills, and card-less cash withdrawal in seconds by using a mobile banking application on their smartphones with an internet connection.

3.5.2 Popularity of use

The concept of "popularity of use" refers to how frequently a product from a particular company, such as "A," is preferred over similar products from other companies, such as "B." The more often a product from "A" is used, the more popular and useful it is considered to be compared to its competitors. This popularity rate is measured within a certain period of time.

However, to analyze the "popularity of use" properly, it is important to consider the concept of "product differentiation." Product differentiation is the process of identifying and highlighting the unique features and qualities of a brand compared to its competitors. Nowadays, there are several digital forums and comment sections available that can convey textual data quickly. This has a direct effect on people's preferences for certain brands over others. Customers seek comfort, happiness, and satisfaction in their lives, and they often derive it from the products they purchase. If a brand consistently delivers a positive experience, customers tend to form a positive opinion about the brand's trustworthiness, which gives them peace of mind when buying products.

Key consideration: several key factors drive customers to choose one brand of a product over a different brand of the same product. These factors include the quality of the service, the customer experience, brand awareness, brand association, and the perceived quality of the brand.

3.5.3 Usage Duration

"Usage duration" is a critical factor that directly impacts the "product usefulness" for users. A product from company "A" that has been used for an extended period, compared to the same product from a different brand (i.e., from company "B"), can be considered more useful. In practical terms, the usage duration of a product can be measured in units of "hours per day." For instance, a product that is used for several hours every day is likely to be more useful than a product that is used only occasionally.

Moreover, the usage duration of a product can also be influenced by factors such as the product's quality, durability, and reliability. A product that has a longer lifespan

or is more durable is likely to be used for a more extended period, contributing to its usefulness. On the other hand, a product that is prone to breakage or malfunctions frequently may have a shorter usage duration, making it less useful.

Additionally, the frequency of updates or upgrades to a product can also affect its usefulness. For instance, a software application that receives regular updates to fix bugs or add new features can continue to be useful to users for an extended period, compared to a product that does not receive such updates. Therefore, companies that prioritize regular updates and upgrades to their products can improve their product's usefulness and attract more customers.

3.5.4 Assessing Product Usefulness

Usefulness (U) = Important level (L) x Popularity of use (R) x Usage frequency (F) x Usage duration (D) (3.3)

It is important to note that the choice of unit for calculating the usage duration may also depend on the type of product and how it is used. For example, for a product like a smartphone or laptop, which is used daily and for extended periods, a unit of time such as hours or minutes may be more appropriate. On the other hand, for products like cars or appliances that are used less frequently, a unit of time such as days or weeks may be more suitable.

Another consideration is the intended use of the product. If a product is designed for continuous use, such as a generator or air conditioning system, a larger unit of time such as months or even years may be appropriate. Similarly, if a product is intended for short-term use, such as a disposable item, a smaller unit of time such as minutes or hours may be more suitable.

The unit of time selected for calculating usage duration should be based on the characteristics of the product, its intended use, and the nature of demand for the product.
Case A: Usefulness Calculation for “Design A: Waterproof-Insulated Storage with Oxford cloth”

Based on the customer feedback, it seems that the waterproof-insulated bag style (Fig. 16) is designed specifically for carrying fresh fruits, foods, and beverages

that require more space. However, customers also mentioned that they have other options to use instead of this bag style, which indicates that it is not the only available option. Therefore, the importance of this bag design is assigned a value of 3.7. Despite being an alternative option, this bag style is still popular among customers due to its affordable price.

Regarding the time spent carrying or holding this bag style, customers reported that it takes around 4 hours, which is not very comfortable even though the bag is lightweight. This discomfort is particularly noticeable when electronic devices or digital gadgets are inside the bag, as there is no supportive element provided. As a result, customers tend to use it intermittently rather than continuously. Thus, the rate of usage for this bag style is identified as 4 hours per day or 4/24.

Calculation of Design A: Waterproof-Insulated Storage with Oxford Cloth

Importance of use (L): Very high (Code B) = 3.7/5 (3.7 scale from the maximum – 5 scales)

Rate of popularity for use (R): 278/400 (ratio of number of target users who have experience with the waterproof-insulated storage/total number of people who could potentially use it)

Rate of use (F × D): 3/24 (ratio of number of hours of use/total number of hours in a day)

Therefore, applying Eq. 3.3 can determine the Usefulness (U) of Design A:

Usefulness (U) = Important level (L) x Popularity of use (R) x Usage frequency (F) x Usage duration (D) **Eq.3.3**

= (3.7/5) × (228/400) × (4/24)

= **0.0703**

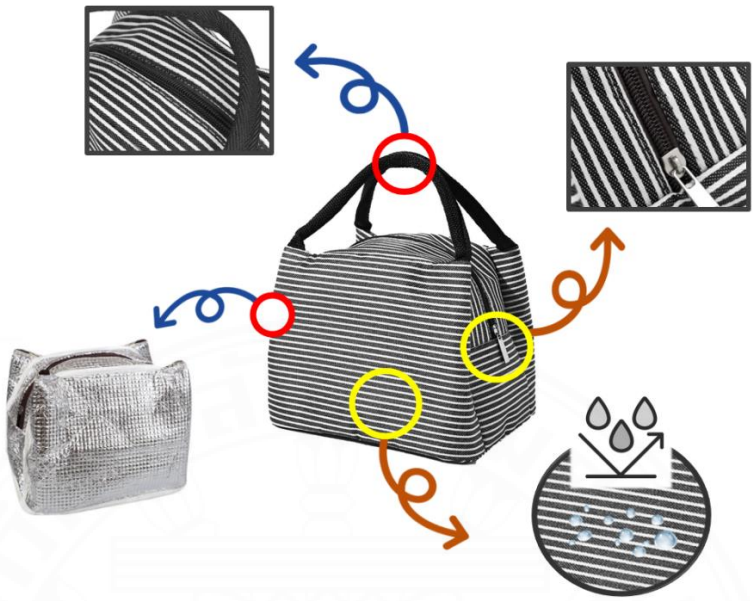


Figure 3.15 Key Considerations from Customer Perceptions on Waterproof-Insulated Storage with Oxford Cloth.

Case B: Usefulness calculation for "Design B: Small briefcase-like style with strap"

To calculate the usefulness of Design B, we need to consider the factors of importance level and usage duration. The importance level of Design B was rated as 4.0, which is higher than Design A. The usage duration was estimated to be around 3 hours per day or 24 hours (6/24). To calculate the usefulness of Design B, we can use the formula:

Usefulness of Design B = Importance Level of Design B x Usage Duration

Substituting the values, we get:

Usefulness of Design B = 4.0 x 6/24 = 1.0

Regarding the **usefulness of Design B**, it has been calculated to have a score of 1.0. This score is lower than Design A, which had a usefulness score of 1.55, based on customer feedback and factors considered. However, Design B is still a popular choice among customers due to its sturdy structure and easy-to-carry design.

Design B is a small briefcase-like style with a strap (Fig. 17). From the customers' viewpoint, this style is preferred over Design A because it can preserve and protect items better than soft fabric or synthetic materials. Despite being heavier than

Design A, its structured plastic handle is ergonomically designed to fit comfortably during holding or carrying, making it an easy choice to grab while traveling during rush hour. Therefore, it has been assigned a higher importance level of "4.0". However, from customer experiences (172 out of 400 - 43%), the price of Design B is higher than that of Design A, resulting in lower sales volume for Design B.

The **time spent** using this type of bag is approximately 3 hours per day or 24 hours (6/24). Even though weight is a main concern for customers, they still choose to use this style throughout the day during work, as it can properly carry and save digital gadgets required for work.

Calculation of Design B: A Small Briefcase-Like Style with A Strap

Importance of use (L): Very high (Code B) = 4/5 (4 scales from the maximum – 5 scale)

Rate of popularity for use (R): 172/400 (ratio of number of target users who have experiences on the simple walking cane/total number of people who could potentially use it)

Rate of use (F × D): 6/24 (ratio of number of hours of use/total number of hours in a day)

Therefore, applying Eq. 3.3 can determine Usefulness (U) of Design A:
Usefulness (U) = Important level (L) x Popularity of use (R) x Usage frequency (F) x Usage duration (D)

Eq.3.3

= (4/5) × (172/400) × (6/24)

= **0.086**

Figure 3.16 Key considerations from customer perceptions on small briefcase handbags.

Discussion – Assessment of the Usefulness of a Product

In this study, the researchers analyzed the usefulness of two different bag styles - a waterproof-insulated bag and a small briefcase-like bag. The researchers assigned a high importance level of 4 to bags/containers/storages since they are necessary for carrying, storing, or keeping important items for everyday life. The researchers suggest that assigning intermediate points to the level of importance could be beneficial in distinguishing among very similar products with the same range of importance level. Although Design A - the waterproof-insulated bag with a lightweight design - is more popular and easier to use, users are worried about carrying electronic or digital items inside because there are no supportive layers like a shock absorber provided. Thus, the importance level of Design A should be less than the Design B, which has a solid structure and a zipper-locking system with a lightweight body.

According to customer perceptions, bags that contain a solid structure and a zipper-locking system with a lightweight body can protect the items inside and are suitable for traveling. With proper sections or compartments provided inside the bag,

users can organize their items and easily access them. Additionally, shock-absorbing materials can be used to protect digital gadgets or tablets.

However, the weight of a briefcase-style bag, even a small one, **is around 1 kg**, which might make users feel fatigued carrying it during the day.

The key guideline for the design stage: the user surveys or research articles can be used to support the decision-making process based on user preferences and the perspective of the design team. The designer obtained the guideline for assessing the usefulness ratio of these products, which is the usefulness **of Design A: usefulness of Design B = 1: 1.22**. This value can be applied as a trend of selling volume when manufacturers start creating or developing a new product.

This can be concluded that a briefcase-style bag with a small size is the proper choice, and its characteristics are interesting to be developed for supporting more activities in various conditions.

CHAPTER 4
CONCLUSION

To further elaborate on the study, product design and development (PDD) using finite element analysis (FEA) was employed to ensure proper design structure. The study focused on a popular bag for women, and customer perceptions and market surveys were taken into consideration during the initial stage. The obtained results aided the researchers in analyzing the market for the specific bag, including investigating customer feelings, expectations, and requirements.

Durability, flexibility, universal design concept, easy-to-access, and easy-to-use functions were identified as ***key points*** based on the target customers' feedback.

In the ***conceptual design stage***, the designer delved into the hidden issues of the waterproof-insulated and briefcase bag structures. The study found that a high percentage of waterproof-insulated bag usage may be inappropriate since only the price is the key factor in the purchasing decision. To assess the usefulness of a product, the researchers used the "usefulness (U)" formula, which is particularly useful for distinguishing among very similar products with the same level of importance. However, the scale of importance of a product is subjective and ranges from 0 to 5, which is why various methods such as user surveys or research articles were employed to support the decision-making process.

For ***material selection and final design***, the designer identified that durable, flexible, portable, and waterproof concepts were key considerations. As such, ABS PC, Aluminum 1060 Alloy, Stainless-Steel, Low-Density Polyethylene (LDPE), Rubber, and Stainless Steel were applied in the design. The virtual model of the bag was designed with air-ventilation (FAN) to maintain the original condition of the items inside the bag. Load-distribution simulation (FEA) was applied to the 3D model, with the critical part being the corner-slot area of the fan since it was not a flat surface for a whole frontal plate.

Key considerations: the study showed that product design and development can benefit greatly from the use of finite element analysis and customer feedback. By considering the key requirements and preferences of the target customers, manufacturers can develop products that meet the needs of their customers while also being durable, flexible, portable, and waterproof.

CHAPTER 5
CONTRIBUTION

In addition to the previous information provided, the design of a bag can also serve as a platform for fashion accessories, where features such as colorful handles, straps, protective cases, and unique handle-curve designs are introduced. However, it is important to consider not only the aesthetics of the bag but also its durability, stability, and the force distributed on the front and back areas as well as the handle. Finite element analysis (FEA) can be a useful tool to support the identification of the proper materials to use in order to achieve these requirements.

Furthermore, the strength of structures with equal cross-sectional area loaded in tension is independent of the shape of the cross-section. This means that regardless of the shape of the cross-section, the strength of the structure is determined by the area that is perpendicular to the applied load. Therefore, the tensile stress, which is the stress caused by an applied load that tends to elongate the material along the axis of the applied load, is an important consideration when designing a bag. This stress is caused by pulling the material and must be considered in order to ensure that the bag can withstand the forces it will encounter during use. By utilizing FEA, designers can simulate the load distribution on the bag and optimize its design to meet the required strength and durability specifications.

Some additional suggestions based on the topic:

- When it comes to bag design, it is important to consider not only the functional aspects but also the aesthetic and emotional appeal of the product. One way to approach this is by using design thinking methodologies, which prioritize empathy, creativity, and user-centeredness in the design process. For example, a designer might conduct interviews or observations with potential users to understand their needs and preferences, generate multiple ideas and prototypes, and test and refine the designs based on user feedback.

- In addition to FEA and other simulation tools, designers can also leverage 3D printing and other rapid prototyping technologies to quickly iterate and validate their designs. This can help reduce the time and cost required for physical testing and production and allow for more experimentation and customization in the design process.
- Sustainability is an increasingly important consideration in product design, and bags are no exception. Designers can explore materials and manufacturing processes that minimize waste, reduce carbon footprint, and enhance recyclability and circularity. For example, using recycled or biodegradable materials, designing for disassembly and repair, or implementing closed-loop supply chains can all contribute to a more sustainable and responsible product.
- User experience (UX) design is another area that can greatly impact the success and satisfaction of a bag product. By focusing on aspects such as usability, accessibility, delight, and emotional connection, UX designers can create experiences that are intuitive, engaging, and memorable for users. This might involve designing intuitive interfaces and interactions for bag features such as zippers, pockets, or straps, creating engaging packaging and unboxing experiences, or leveraging augmented reality or other digital technologies to enhance the product experience.

CHAPTER 6
RECOMMENDATION

To further enhance the design of the work-and-travel bag, it is also important to consider the ergonomics of the product. The bag should be designed to minimize discomfort and stress on the user's body, especially if it will be carried for extended periods of time. The weight distribution of the bag should be balanced, and the straps should be adjustable and padded for comfort.

Additionally, the bag should have multiple compartments and pockets to provide organization and easy access to items. The design should also incorporate security features such as lockable zippers and RFID blocking technology to protect valuable items.

Moreover, sustainability and environmental concerns should also be taken into account in the design and material selection process. Using eco-friendly materials and reducing waste during manufacturing can make the product more appealing to environmentally conscious customers.

By taking into consideration customer needs, ergonomics, security, and sustainability, the work-and-travel bag can be designed to not only meet functional requirements but also offer added value to customers.

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