Application of Decision Matrix in Pan Handle Model Evaluation Based on Product Design Specifications

Silmy Faridhatul Husna, Hanifah Widiastuti, and Rahman Hakim

∗ Politeknik Negeri Batam
Program Studi Teknik Mesin
Jl. Ahmad Yani, Batam Centre, Batam 29461, Indonesia
[1]E-mail: silmyhusna@gmail.com

Abstract

The research focuses on cooking tools, such as pans and pots with detachable handles, which require careful model selection to ensure usability and efficiency. The goal is to identify the most suitable pan handle design, enhancing daily living for the elderly and improving overall product satisfaction and production efficiency. Utilizing the Decision Matrix method, this research aims to quantitatively evaluate various pan handle models based on Product Design Specifications (PDS). The final chosen pan handle design will be considered with more further improvements.

Keywords: Decision matrix, product design specifications, evaluation

1. Introduction

The creation of a new product is usually due to a high consumer need for a product. or sometimes the product is still rarely on the market but is very necessary for some people. For example, elderly people who have limited movement in carrying out daily activities. By 2050, it is projected that one in four people in the UK will be aged 65 and over - up from around one in five in 2019.[1] Common issues such as arthritis or loss of physical strength affect the older population, reducing agility and precision when performing everyday tasks. Likewise, loss of physical acuity over time can make it challenging to operate product functions when compared to younger populations.

Their limited mobility also interferes with their daily activities such as cooking. Inclusive design is needed for them and applied to cooking tools like pans and pots that have detachable handles. Choosing the right handle model is also very important to ensure the quality and efficiency of the product. Model selection also requires in-depth evaluation, as each model has different advantages and efficiency levels. Therefore, a method is needed to obtain objective evaluation results for the handle.

The Decision Matrix method is one approach that can be used for this purpose. The Decision Matrix allows for a quantitative evaluation of various alternatives by considering several predetermined criteria. This method helps identify the model that best meets the needs based on the importance weight of each criterion.[2] When evaluating using the decision matrix, a reference specification is needed to make an assessment in the form of a product design specification. Product Design Specifications (PDS) is a crucial document defining the requirements and characteristics that a product must meet. PDS includes various aspects such as materials, dimensions, ergonomics, and performance, all of which play a role in determining the suitability of a pan handle model.[3]

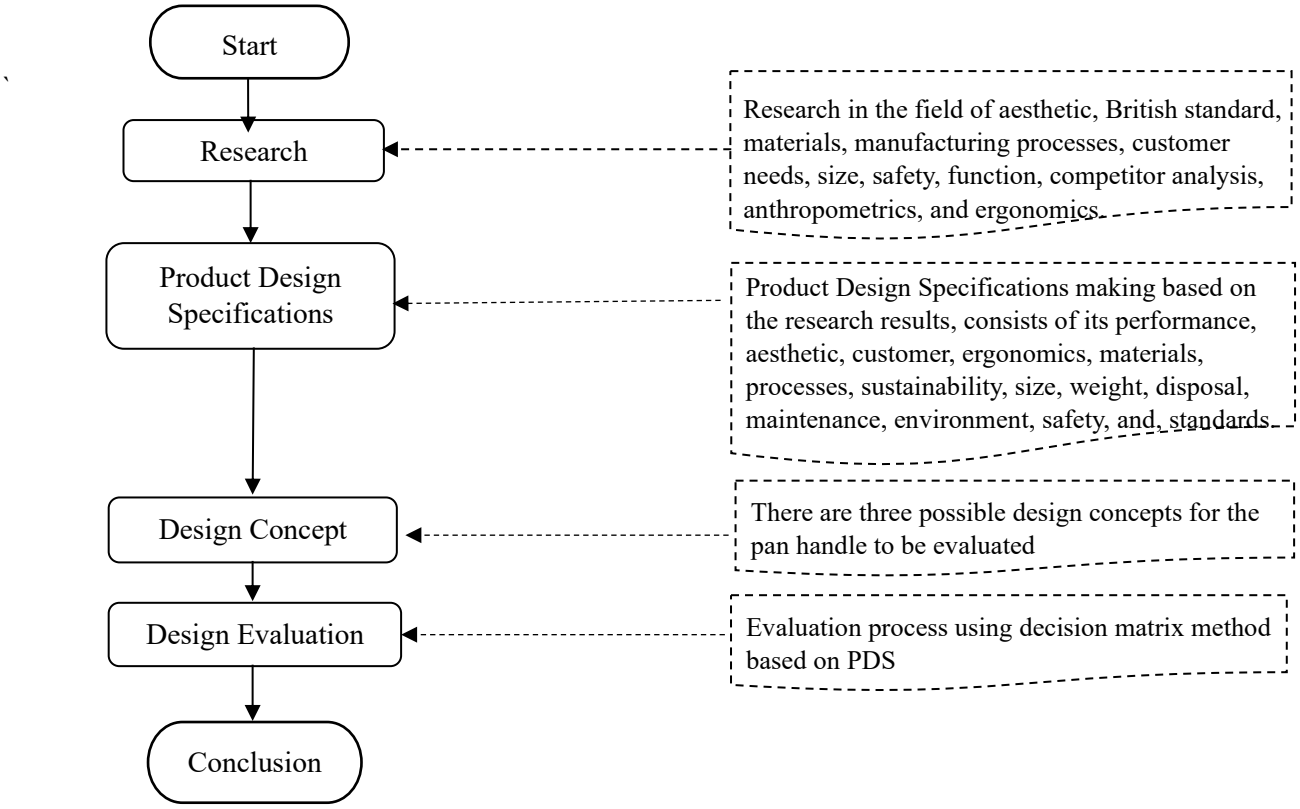
This product consists of pots, pans and detachable handles but focuses on the selection of pan handles only, pots and pans as additional media. This research aims to apply the Decision Matrix method in evaluating pan handle models based on Product Design Specifications, with a particular emphasis on inclusive design for individuals with limited hand capabilities. By using this approach, it is expected to find the most optimal pan handle model, thereby improving production efficiency, and enhancing user satisfaction.

2. Methodology

2.1 Procedure

This project was conducted in groups during the Conceptual Design module at the University of Portsmouth, United Kingdom.

FLOWCHART



2.2 Stages

1. Research

   The initial stage is to conduct research in the fields of aesthetics, British standards, materials, manufacturing processes, customer needs, size, safety, function, competitor analysis, anthropometrics, and ergonomics. It is considered to ensure that the products produced align with their users' needs.

2. Product Design Specifications

   A PDS document outlines all of the criteria, limitations, and standards to which a new product must meet. It should be a concise list that includes extensive information on each area of the design brief. It includes research findings on performance, aesthetics, customers, ergonomics, materials, processes, sustainability, size, weight, maintenance, environment, safety, standards, and disposal.

3. Design Concept

   There are several design sketches for the possible pan handle made based on the research.

4. Design Evaluation

   The decision matrix method is used for evaluating the design sketches to get the final design concept based on the PDS. Every design sketch will be rate on a 1 to 5 scale, with 5 being the best; weight is on a 1 to 5 scale, with 5 being the most significant. The solution with the highest overall weighted score was selected for additional development

5. Conclusion

   This stage is a conclusion and evaluation of the application of decision matrix evaluation method for pan handle design.

3. Data Analysis and Discussion

3.1 Research

The product is a modular cookware item with an intense focus on inclusive design for the Panhandle. The concept of inclusive design aims to use a human-centred design approach to produce products that are available to the broadest range of individuals in terms of ethics, usability, accessibility, and equity. Secondary data was acquired to better understand the scope of the project, allowing for the production of an accurate PDS.

1. Aesthetic

The majority of commercially available pots and pans for domestic use are fairly plain in appearance. They are frequently made of stainless steel and may have a nonstick coating on the inner basin, as well as an alternative or additional thermally insulating material for the handle, such as silicone, rubber, or wood. Some pots feature a coloured exterior or handles.

2. British Standard

It is essential for the product's commercial viability to comply with all applicable standards; this guarantees that the product fulfills all of the item's safety and performance criteria for home use. The standard that has the largest effect on the design process for our product is BS EN 12983-1:2023.[4] The Product Design Specification demonstrates the entire implementation of this standard.

BS 7373-3:2005[5] this was used as guidance to create the PDS. The PDS document also details all other British standards that apply to all elements of manufacturing and marketing a design inclusive cookware item.

3. Material

Pots and pans are presently made from a wide range of materials and combinations. This consists of cast iron, enamelled cast iron, stainless steel, carbon steel, copper, aluminium, and ceramics.[6] The most significant materials for the new product design are stainless steel and aluminium. This is due to the fact that they are the lightest of the materials, allowing the product to remain integrated into its design.

Table 1
Advantages and Disadvantages of Stainless Steel and Aluminium

Stainless Steel	Aluminium
Advantages	
Non-Reactive, this will not have an impact on the taste of the food once cooked	More versatile in terms of aesthetic
Heats up quickly	Retains heat well
Dishwasher Safe/ Oven Safe	Lightweight and affordable
Strong and Durable	
Available in different finishes	
Disadvantages	
Not the most efficient for heat distribution	Reactive to certain foods
Tougher to clean for burnt food items	Washing an aluminium pan in a dishwasher may cause a change in appearance.
Non-stick coating requires extra processing, which increases the product's cost.	

Table 1 indicate the mechanical characteristics of each material, which support the advantages and disadvantages of each. To develop a pan with the appropriate functionalities, certain businesses commonly use a multilayer construction of stainless steel and aluminium, as well as nonstick coatings. Polytetrafluoroethylene (PTFE) is the most common lightest and affordable non-stick coating; nonetheless, the coating may scratch or peel with time, resulting in the release of toxic chemicals during the cooking process, particularly if aluminium was used as the base material.[7] PTFE is known to produce hazardous gases at temperatures above 260 °C, and its coating is not biodegradable.[8] Infused titanium is a popular alternative nonstick coating because it is non-toxic, resistant to acid degradation,

and provides a longer lifespan and even heat distribution,[9] resulting in faster temperatures for a similar price.

Table 2
General Properties of Stainless Steel and Aluminium

General Properties	Stainless Steel	Aluminium	Unit
Density	7.61e3	2.65e3	Kg/m^3
Price	2.17	1.55	Gbp/kg
Date first used	1915	1905	

Table 3
Mechanical Properties of Stainless Steel and Aluminium

Mechanical Properties	Stainless Steel	Aluminium	Unit
Young's modulus	190	69	GPa
Shear modulus	74	26	GPa
Bulk modulus	140	66	GPa
Poisson's ratio	0.27	0.32	
Yield strength (elastic limit)	257	118	MPa
Tensile strength	515	193	MPa
Compressive strength	252	109	MPa
Elongation	10	1.2	% strain
Hardness – Vickers	170	83	HV
Fatigue strength at 10^7 cycles	256	63	MPa
Fracture toughness	57	19	MPa.m^0.5
Mechanical loss coefficient (tan delta)	3.1e-4	0.003	

Table 4
Thermal Properties of Stainless Steel and Aluminium

Thermal Properties	Stainless Steel	Aluminium	Unit
Melting point	1.4e3	535	ºC
Maximum service temperature	640	138	ºC
Minimum service temperature	-150	-273	ºC
Thermal conductor or isolator?	Poor conductor	Good conductor	
Thermal conductivity	14	110	W/m.ºC
Specific heat capacity	450	944	J/kg.ºC
Thermal expansion coefficient	10.8	19.5	µstrain/ºC

4. Manufacture

Frying pans are manufactured in a series of phases, beginning with the design of the pan and ending with nonstick coatings and finishing touches. The specifics may vary based on the pan's material, size, and intended characteristics, but the overall procedure is similar. Frying pan producers start by designing the product, which involves determining the pan's size, shape, and features. The acceptable materials are stainless steel, aluminium, copper, and cast iron. The selected material is shaped into the shape of the pan using several processes, including stamping and spinning. The created material is subsequently trimmed to the desired size and shape by tools like laser cutters, water jets, and shears. The pan is then polished to eliminate any rough edges and give a flawless surface, before being packed for transportation.[10]

5. Customer

Customers or users of this product typically people who cook for themselves or others at home. To make this product as accessible as feasible, all forms of user limitations or disabilities must be considered during the design process. A cookware product's design may need to take into account a wide range of user characteristics, such as people with poor vision or blindness, colour blindness, sensory issues with

texture, colour, reflectiveness, or pattern use, that require the use of two hands or arms, or the need for all or specific fingers. The design should evaluate how much, if any, users from various backgrounds would engage with the product, anticipate challenges that users may encounter, and minimize them during the design process.

6. Size

Table 2 provides a comparison of pan sizes from three different brands: All-Clad, Le Creuset, and Lodge. Each brand offers unique pan measurements, including the length, width, and height.

Table 5
Comparison of Pan Size

Size (cm)	Brands		
	All-Clad	Le Creuset	Lodge
9	-	-	15.2 x 10 x 2.3
12	-	-	19.5 x 12.5 x 2.7
15	-	-	25.8 x 17 x 3.4
20	37.5 x 21.8 x 8.3	38.4 x 21.1 x 6.6	32.3 x 22 x 4.7
22	-	40.3 x 23.1 x 6.85	35 x 24.5 x 4.7
24	-	45 x 25.1 x 7.6	-
25	45.4 x 26.6 x 12	-	-
26	-	46.9 x 27.1 x 7.6	41 x 27 x 5
28	-	49 x 29.1 x 7.6	-
30	50 x 31.7 x 11	50.9 x 31.1 x 7.8	45.7 x 32 x 5.7
33	-	-	20.75 x 52.7 x 7.1
38	-	-	56.3 x 38 x 7.2

[11][12]

This information is essential since the pan's size can influence a variety of suitable parameters. When acquiring a new pan, buyers have to understand the size of the pan offered. They may choose a pot that suits their stove size and satisfies their cooking needs by understanding the pan's height, diameter, and capacity. Knowing the size of a pan ensures that a purchase can qualify for easy storage without using up too much space in a kitchen with limited storage. The pan size influences how effectively energy is used. By matching the pan's diameter to the stove, you may optimize heating efficiency while saving energy and cooking time. Some meals may call for a larger or smaller pan. This information helps users in selecting a pan suited for the various types of foods they wish to make. By comparing pan sizes amongst companies, consumers may pick a brand that matches with their tastes, whether based on quality, style, or additional features.[13]

7. Safety

The general safety standards of BS EN 12983-1:2023 as well as the testing procedures used to meet them. It also involves the quality of the materials used to create the modular cookware item; there must be no hazardous dangers or any effect on the chemical composition of the food prepared. This is why it is critical to analyse materials carefully. Additionally, any attachments made to the pan's body must be free of cracks and blisters following adequate testing.

According to BS EN 12983 Mechanical Hazards, the product must be free of scratches, splinters, and sharp edges that might cause the user pain or discomfort. This is especially crucial when hand cleaning the pan.

The handle's height from the base must be at least 30mm, measured from the midway point. This is done to guarantee that the user is exposed to as little heat as possible, lowering the danger of scolding and burns. To pass the safety test, the pan must be able to survive 15,000 cycles of handle fatigue with less than 5% deformation.

All general guidelines for maintaining the product properly should be included in the instruction manual. Warning against inappropriate pre-heating, dry heating, and failure to maintain sufficient attendance

when using the device.

8. Function

Cookware with a non-stick coating has advantages above merely being easier to clean. It's ideal for pancakes, omelettes, and fish fillets since it allows you to cook delicate foods without fear of them breaking or sticking. Furthermore, the nonstick surface promotes healthy cooking by reducing the need for unnecessary cooking fats or oils, resulting in lower-calorie meals.

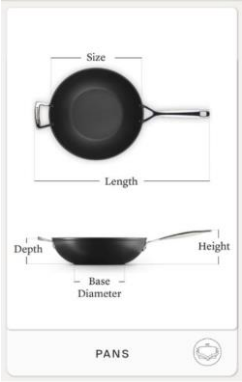
9. Competitor Analysis

1. Le Creuset Signature Stainless Steel Shallow Non-stick Frying Pan

The Le Creuset Signature Stainless Steel Shallow Nonstick Frying Pan is comprised of three layers of material: stainless steel and aluminium.[14] The pan's main body is composed of stainless steel, and the basin is nonstick coated.

Picture 1: Le Creuset Signature Stainless Steel Pan

The pan can withstand temperatures of up to 260 degrees Celsius and is suitable with any grill, oven, electric hob, ceramic glass cooktop, gas hob, and induction hob. The pan also works with freezers and dishwashers. The pan is available in three sizes, and the price varies depending on the size chosen. The 20centimeter size costs £145, the 26 cm size is £179, and the 30 cm size is £199.



Picture 2: Pan Dimension

2. InGenious Lazy Man Frying Pan – Multiple Hob 5-in-1 Breakfast Cooking Skillet

The pan is composed of aluminum with an Xylan nonstick coating.[15] It includes five sections: a griddle pan in the center, an egg pan in the top left and bottom right corners, a normal frying pan in the bottom left, and a dimpled griddle pan. It is compatible with all traditional hob types, including gas, electric, halogen, ceramic, and induction. The pan weighs 1.46 kilos and has overall dimensions of 50.1 x 42.5 x 8.7 cm.

Picture 3: InGenious Lazy Man Frying Pan

3. Tesco Basic Aluminium Frying Pan

This pan is constructed of aluminum, is dishwasher safe, and may be used on all types of hobs except induction.[16] The pan features a black basin, body, and handle. The handle's composition is not revealed, however, it looks like a polymer or a poor heat conductor. The pan costs £3.50 and has a 4.1 out of 5 rating from 17 reviews. The pan has a base size of 24 cm.

Picture 4: Tesco Basic Aluminium Frying Pan

4. TEFAL Ingenio Easy Cook & Clean 5 Piece

This cookware set consists of two pans (22 cm and 28 cm), two pots (16 cm and 20 cm), and a removable Ingenio handle.[17] The three-point mechanism in the handle allows it to safely carry up to 10kg and comes with a 10-year guarantee.

The design allows consumers to save storage space by employing one handle to hold multiple pots and pans. The detachable handle also makes the pots and pans multi-functional, enabling them to be used as oven dishes, bakeware, service dishes, and refrigerator food storage containers.

The pots and pans have titanium nonstick coatings on both the interior and outside. They also include Thermo-Signal technology, which causes the hourglass on the basin to vanish, signalling to the user when the pan is hot enough to sear. The diffusion base enables the pan to heat evenly. The pots and pans are made of aluminium and may be used with gas, electric, ceramic, or halogen heat sources. The pots feature an outwards curved lip that makes pouring easier.

Picture 5: TEFAL Ingenio Easy Cook & Clean 5 Piece

10. Anthropometrics and Ergonomics

Measurements in Table 3, Table 4, and Table 5 are all in centimetres.

Table 6
Palm Width of Adults

Palm width			
Demographic	Percentile		
	2.5	50	97.5
Adult male	9.4	10.4	11.4
Adult female	8.6	9.1	10.4

[18]
The diameter of the inside of an adult human hand is the same for both men and women.

Table 7
Average Adult Percentile

Average Adult			
Body measurement	Percentile		
	2.5	50	97.5
Inside grip diameter	4.1	5.1	5.3

The grip line on an adult hand is 12 degrees from the normal of the wrist. This angle can be used in conjunction with the palm width to calculate the grip line along the hand.

Table 8
Grip Line Length Percentile

Grip line length	Percentile		
	2.5	50	97.5
Adult male	9.61	10.63	11.65
Adult female	8.72	9.30	10.63

The grip line length and inside grip diameter can be used to determine the dimensions for the handle design.

3.2 Product Design Specifications

This PDS was produced utilizing several sources, which are cited as needed throughout the document. This document contains the necessary information to create a comprehensive PDS that is quantifiable and measurable toward the designed product following the BS 7373-2 Product Specification.

1. Performance

This section includes all of the requirements stated by features, as well as features related to the product's function, quality, dependability, and durability. The product's functional aspects include heating and cooling rates, nonstick coating performance, handle design, and overall ease of use, which are all specified in the PE(n) points below.

PE.1. Ease of use
PE.1.1. The product has an intuitive design. The user will not need to put in much work to comprehend how the product should be used properly.
PE.1.2. The distinct compartments allow users to cook many foods at the same time.
PE.1.3. Pictorial infographics will be included on the package and in the product handbook to help customers comprehend the product's intended usage.

PE.2. Heating and Cooling
PE.2.1. It should take 1.5-5 minutes for the pan has reached an even internal surfacetemperature of 160°C at which point the flame logo will disappear.

PE.3. Handle

PE.3.1. The handle should be able to withstand 15000 cycles in a fatigue test outlined in BS 12983-1:2023, point 7.10 Fatigue Resistance code, page 12 and further test specifications found in Annex A page 17

PE.3.2. Instructional videos and pictorial infographics will be provided for the proper use of the Handle, on the website and via QR code links on the packaging as well as the product manual.

2. Aesthetics

The product's form and look must not interfere with the user's ability to operate the product.

AE.1. The product's edges must be blunt and the finish smooth to ensure that it is comfortable to grasp and clean.

AE.2. The colours and colour combinations used on the product should be visible to red-green colourblind users (the most prevalent kind).

AE.3. To assist persons with impaired eyesight, the colours chosen should be in strong contrast to other hues.

AE.4 Use unnecessary ornamentation, colours, patterns, and textures sparingly, if at all.

3. Customer

This product was designed with inclusivity in mind; to do so, it must accommodate the maximum number of users while taking into consideration user capacity and aptitude. Anthropometric data was used to determine the ideal size and weight of the handle for the users.

CU.1. Users must be physically capable of holding a pan weighing up to 5kg in one arm at an average cooktop height (88-94cm).

CU.2. Users must have enough dexterity to use the locking and unlocking mechanism located in the handle.

CU.3. The handle should be devoid of finger grooves, allowing users with many fingers to operate it comfortably.

CU.4. The handle should have a smooth feel to minimize sensory overload.

CU.5. The handle should be black with no design to avoid visual overstimulation.

4. Ergonomics

Ergonomic considerations were addressed to guarantee that the product could be used to its full potential.

ER.1. The handle should be usable in the left or right hand.

ER.2. The handle will be designed to meet the 97.5% ergonomic percentile for hand grip line length.

5. Materials

According to BS 12983-1:2023, “Cookware shall be made from materials with a level of purity that, under normal conditions, do not produce toxic hazards to the organic elements of the foods prepared in it”. This combination of layers, in the order given provides the product the maximal advantages of each material.

MAT.1. The pan has a layered construction, with the outermost layer being stainless steel, which was chosen for its appropriateness for induction hobs. It is highly durable and has a short heat up time.

MAT.2. Aluminium was chosen as the core due to its ability to heat uniformly and retain heat. This material is also light and inexpensive.

MAT.3. Titanium was chosen as the layer that gives the pans with dividers since it is also the material utilized for the material's nonstick coating. This is because it has a larger potential for recycling than PTFE. Titanium is also non-toxic, resistant to acid breakdown, and wear-resistant. This makes the material appropriate for its intended application.

MAT.4. Coatings must be tested in line with ISO 2747 to ensure they fulfill the required thermal shock criteria.

MAT.5. A titanium coating with a Protection rating of 10 should be applied. This ensures the coating protects the base metal from corrosion while maintaining its non-stick properties and beauty.

MAT.6. Thermochromic paint should shift from coloured to transparent at around 160°C.

MAT.7. Glass makers must guarantee that their materials fulfill the precise standards stated in BS 12983-2:2023. "The lid of a utensil shall have a thermal shock endurance at $\Delta t50$ no less than 150◦C when tested in accordance to EN 1183."

6. Processes

The manufacturing process for frying layered frying pans:

PR.1. Blanking

This technique cuts sheet metal to the required size, preparing it for the next stage of the production process. This was chosen due to its moderate labour intensity, medium relative tooling cost, and relative equipment cost. This method is also suitable with the materials we have chosen. This method may also provide smooth surface roughness and manufacture the item to the required thickness.

PR.2. Bending

This technique forms the sheet metal into the required shape. It was selected for similar reasons as the Blanking manufacturing technique.

PR.3. Diffusion and glaze bonding

This procedure combines all of the elements generated to form the final product. This technique was chosen for its low relative tooling cost, medium relative equipment cost, and labour intensity. This technique is compatible with all joint geometries found in the Product.

PR.4.Thermocromatic paint adhesion

This stage is required for the overall functionality of the design solution. This is where the flame is etched into the pan's surface and the paint adheres.

PR.5. Vapour Metallizing (PVD)

The nonstick coating is then applied using this method. This procedure was chosen because it is compatible with the materials used, provides the product with all of the necessary additional protection, and retains product functioning. It has a cheap relative tooling cost, requires little effort, and delivers a flawless surface finish.

PR.6. Finishes

Throughout the procedure, a succession of typical machining methods were used to guarantee that the result had the desired overall look. This comprises turning and boring, which have a high relative equipment cost, medium labour effort, and relative tooling cost. The next step is to polish the product to remove burrs, splinters, and sharp edges.

7. Sustainability

SU.1. The materials used should be responsibly and legally sourced in accordance with national and international laws.
SU.2. The manufacturing process should take the fewest amount of steps to make the product.
SU.3. Renewable energy shall account for at least 15% of total process energy.
SU.4. The product should contain at least 25% recycled materials.

8. Size

SI.1 Handle

SI.1.1. The handle's height from the base must be at least 30mm measured from the midway point of the handle when it is fastened to the pan.
SI.1.2. Dimensions of at least 11.65cm in length and 5.3cm in diameter, calculated using the 97.5% male percentile measurement for hand length.

SI.2. In accordance with BS12983, “the capacity of all the cookware product shall be within atolerance of ±0.05ml level of accuracy.”
SI.3. In accordance with BS12983, “Diameters of all pots and pans should be within a tolerance of ± 10 mm taken at right angles to one another.”
SI.4: Pots and pans should have a thickness of 2.3-2.7mm. At this thickness, the product provides the appropriate mechanical qualities.
SI.5. Requires lids to fit pots and pans with the sizes stated in SI.3, ensuring a sealed fit.
SI.6. Pots and pans' base diameter shall be clearly mentioned on packing.

9. Weight

WE.1. The product's weight must be competitive with existing items on the market and not exceed 2 kg. This is done to guarantee that there are as many users as feasible while maintaining design inclusiveness.
WE.2. The handle shall weigh no more than 500g and be able to support weights of up to 10kg for 1-hour periods without sliding. This assures that it is fully functioning in its intended design context.
WE.3. The lids should weigh no more than 600g to keep the overall weight of the product considerably below the client specification CU.1 of 5 kg.

10. Maintenance

MA.1. Cleaning

MA.1.1. After usage, allow the product to cool before cleaning. Then use a dishwashing sponge, scouring pad, or dishwashing brush to clean with detergent.
MA.1.2. The product should not be cleaned with harsh equipment such as steel wool or detergents/chemicals that are not designed for dishwashing. Cleaning using a dishwasher is not suggested since it may not be completely clean afterward.

MA.2. Storage

MA.2. The product may be used and kept in a variety of environments, however consumers should be warned of too much shock temperatures in order to extend its life. This implies that the pan and its attachments should not be exposed to freezing temperatures before quickly transitioning to boiling temperatures.

MA.3. Service life

MA.3. With an average cooking time of 40 minutes and three uses per day, the product should perform optimally for at least ten years. when utilized in accordance with the product usage directions provided to the consumer in the product handbook.

11. Environment

EN.1. The product may be used on residential hobs (gas, electric, halogen, induction).
EN.2. The product can withstand temperatures up to 300°C.
EN.3. The product shall be suitable for use in an oven up to 300°C.
EN.4. The product should be acceptable for use in the fridge up to -3 °C.

12. Safety

The product handbook should also include all required instructions for the correct safe use of the goods, and in case the product proves to be unsatisfactory, the company's name and contact information will be included so that customers may have their complaints heard. The general safety caution for this product is that it is not microwave compatible.
SA.1. Do not let pans boil dry. If this happens, let it cool before removing from heat. The appropriate preheating approach is to add a little oil in the pan and let the pan to rise to temperature slowly, as indicated by the flame diminishing.
SA.2. Ensure that the room is well always ventilated when cooking.
SA.3. A medium-high degree of attendance is required while using the pan to cook meals on the stovetop, and a low-medium level of attention when using it in the oven. This helps to avoid accidents and lowers the risk of fire.
SA.4. Lifting lids from a cooking pot/pan should be done with caution, as they may be heated. Use a glove or towel. To avoid scolds and burns, be mindful of any water vapour that may be expelled from a hot pan or pot. Avoid putting lids on hot stovetops and chilling them with cold water.
SA.5. Take caution while moving the pan because it might be heavy for certain people who are preparing meals. This product should not be used outside of its intended application, as it may cause damage to the user. Avoid deep frying.

13. Standards

In order to trade this product within the EU the Product must conform to all the EU Standards listed below.
ST.1. All of the pots and pans will conform to EU Food Contact Materials Framework Regulation (EC) 1935/2004.
ST.2. All of the pots and pans will conform to Good Manufacturing Practice for FCM Regulation (EC) 2023/2006 (Good manufacturing practice for materials and articles intended to come into contact with food.).

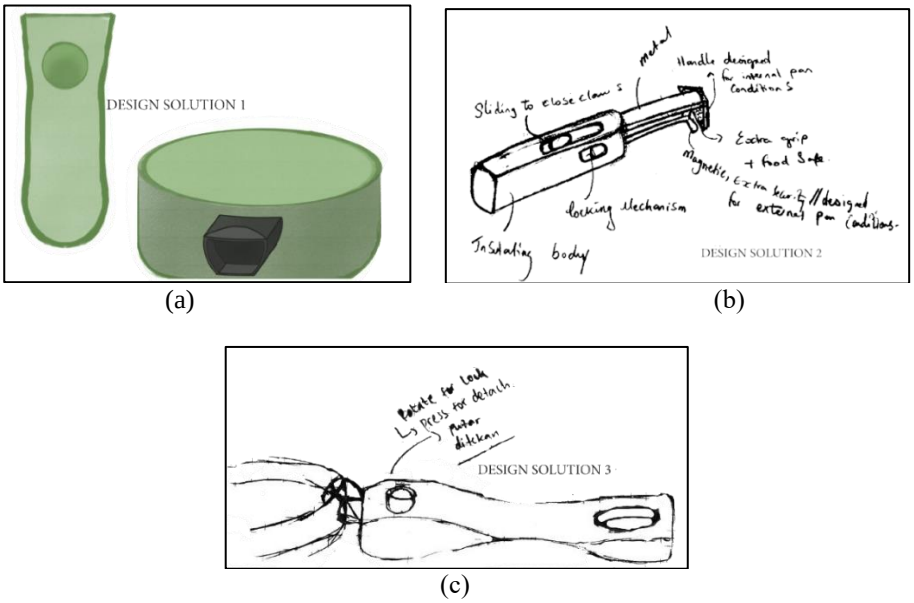
ST.3. All of the pots and pans will conform to General Product Safety Directive.
ST.4. All of the pots and pans will conform to EN 12983-2 – Cookware – Domestic cookware for use on top of a stove, cooker or hob – Part 2: General requirements for ceramic cookwareand glass lid.

14. Disposal

The company's disposal procedures are in accordance with BS EN 50625-1:2014 Collection, Logistics, and Treatment regulations for WEEE. General treatment standards provide the most information necessary to allow the product's correct collection, recovery, recycling, and ecologically responsible disposal.
DI.1. This product will have the correct marking to indicate that it can be disposed of in general waste.
DI.2. Provide the most detailed information on the correct disassembly of the product's accessories for recycling as available on the business website, packaging, and product manual.
DI.3. Customers that want further assistance with the recycling process will benefit from our product's dismantling training videos. The website will also include connections to their local recycling facility. To promote the value of sustainability, we make recycling as accessible as possible.
DI.4. Customers will be encouraged to donate the goods or accessories if they have just outgrown the use of the device and it is still in excellent working condition.
DI.5. The company will implement a return and redemption plan to encourage consumers to return their pots and pans, which will then be disposed of and recycled appropriately.

3.3 Design Concept

The design solution is a cookware set that includes a pan with a detachable handle. The detachable handle is intended to make it easier for persons with special needs to cook with only one hand. There are three design options for the pan handle.



(a) (b)

(c)

Picture 6: Design Solution for The Handle (a)Design Solution 1 (b)Design Solution 2 dan (c)Design Solution 3

3.3.1 Design Solution 1

The handle is elongated with a circular element near the top, likely part of the attachment mechanism. To attach the handle to the pot, the user aligns the circular element on the handle with the dark element (connector) on the pot. The handle is then pressed into place until it locks securely. Once attached, the handle allows the user to safely lift and move the pot. To release, the user would press a button or release the latch mechanism on the handle to disengage it from the pot.

3.3.2 Design Solution 2

To attach the handle to the pan, the user aligns the sliding connectors on the handle with corresponding slots on the pan. The user slides the handle into place, engaging the connectors. The locking mechanism

and safety trigger ensure it clicks securely. Once attached, the handle provides a secure and comfortable grip for moving the pan. To remove the handle, the user engages the safety trigger or release mechanism. This disengages the lock tab and latch tip, allowing the handle to slide off smoothly.

3.3.3 Design Solution 3

When the handle is aligned with the pan, pressing the lever engages the locking mechanism. The mechanism likely involves a pin or catch that fits into a corresponding recess on the pan, ensuring a secure attachment. To detach the handle, the user needs to press the lever again. This action disengages the locking mechanism, allowing the handle to be safely removed from the pan.

3.4 Design Evaluation

Pan handle design evaluation using the decision matrix method based on the PDS that has been made above. Not all points in the PDS are used as assessment benchmarks, only a few points. It is because not all the points can be directly assessed by the product. Out of three designs which one best suit the PDS and based on that, the final design was chosen.

Ratings are also on a 1 to 5 scale, with 5 being the best; weight is on a 1 to 5 scale, with 5 being the most significant.

Rating Scale (1 to 5):

1. Poor
   The item or performance is far below expectation. It shows significant issues, defects, or shortcomings towards the PDS.
2. Fair
   The item or performance is below average. It has noticeable flaws or issues that affect its overall quality or usability towards the PDS.
3. Good
   The item or performance meets expectations. It has minor flaws but is generally reliable and effective towards the PDS.
4. Very Good
   The item or performance exceeds expectations. It is high quality with only a few minor issues towards the PDS.
5. Excellent
   The item or performance is outstanding. It is of the highest quality, with no significant issues towards the PDS

Weight Scale (1 to 5):

1. Insignificant
   This aspect has very little impact on the overall evaluation. It can be ignored without much consequence.
2. Minor
   This aspect has some impact but is not crucial to the overall evaluation. It is somewhat important but not critical.
3. Moderate
   This aspect has a noticeable impact on the overall evaluation. It is important but not the most critical factor.
4. Significant
   This aspect has a substantial impact on the overall evaluation. It is very important and influences the decision considerably.
5. Critical
   This aspect is of utmost importance to the overall evaluation. It is the most significant factor and can make or break the decision.

With the best features of each design taken into consideration as opportunities for progress, the solution with the highest overall weighted score was selected for additional development.

Table 9
Decision Matrix Evaluation

PDS Point Code	Weight	Design Solution 1		Design Solution 2		Design Solution 3	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
PE.1.1.	4	4	16	3	12	4	16
PE.3.1.	5	5	25	4	20	3	15
AE.1.	5	5	25	4	20	3	15
CU.3.	3	5	15	5	15	5	15
CU.4.	3	4	12	4	12	3	9
CU.5.	3	2	6	4	12	4	12
ER.1.	4	4	16	4	16	4	16
SI.1.2	5	4	20	5	25	5	25
EN.1.	5	5	25	5	25	5	25
SA.5.	5	5	25	4	20	3	15
Total Score			185		177		163

The chart above clearly shows that design solution 1 had the greatest need for functionality, which will be implemented in the final design of the handle. Design solution 1 performed badly against PDS point CU.5. To avoid visual overstimulation, the handle should be black and without any patterns. This is readily fixable. At this point, the handle design solution has an 88% accuracy rate. Following the first design review, enhancements were made to fully comply with the specific necessary standard listed in the PDS's Standards section, as well as to take into account broader environmental, sociological, and economical design aspects.

4. Conclusion

In summary, the study conducted resulted in the creation of a distinct product that is commercially feasible. A product design specification was created after an additional review of the design process, which was fueled by the conducted research. The final design does not entirely fulfill the Product design standard, but it scores rather well; further attention to detail will be necessary to ensure that the product meets the PDS. The expected project outputs have been developed and are awaiting comment.

5. References

[1] Overview of the UK population January 2021, (n.d.).

[2] 7 Quick Steps to Create a Decision Matrix, with Examples [2024] • Asana, (n.d.). https://asana.com/resources/decision-matrix-examples (accessed March 19, 2024).

[3] What is a product design specification (PDS)? - Technical Foam Services, (n.d.). https://technicalfoamservices.co.uk/blog/what-is-a-product-design-specification-pds/ (accessed March 19, 2024).

[4] PDF Viewer::BSOL British Standards Online, (n.d.). https://bsol.bsigroup.com/PdfViewer/Viewer?pid=000000000030106093 (accessed June 12, 2024).

[5] PDF Viewer::BSOL British Standards Online, (n.d.). https://bsol.bsigroup.com/PdfViewer/Viewer?pid=000000000030406223 (accessed June 12, 2024).

[6] Types of Cookware Materials & The Pros and Cons - Jessica Gavin, (n.d.). https://www.jessicagavin.com/types-of-cookware-materials/ (accessed June 12, 2024).

[7] Different Nonstick Pan Types, (n.d.). https://mealprepify.com/types-of-non-stick-coatings/ (accessed June 12, 2024).

[8] Is Nonstick Cookware Like Teflon Safe to Use?, (n.d.). https://www.healthline.com/nutrition/nonstick-cookware-safety (accessed June 12, 2024).

[9] Regular Nonstick Pan vs Titanium Nonstick Pan - What's the Difference?, (n.d.). https://worldofpans.com/regular-nonstick-pan-vs-titanium-nonstick-pan/ (accessed June 12, 2024).

[10] Metalworking Machinery Manufacturer for Sheet Metals, (n.d.). https://ems-metalworking.com/ (accessed June 12, 2024).

[11] What Size Wok Do I Need? | Lodge Cast Iron, (n.d.). https://www.lodgecastiron.com/story/what-size-wok-do-i-need (accessed June 12, 2024).

[12] LC_MEASUREMENTSGUIDE_EN, (n.d.).

[13] Size Matters - by Andrew Janjigian - Wordloaf, (n.d.). https://newsletter.wordloaf.org/p/size-matters (accessed June 12, 2024).

[14] Signature Stainless Steel Shallow Non-stick Frying Pan | Le Creuset UK, (n.d.). https://www.lecreuset.co.uk/en_GB/p/signature-stainless-steel-shallow-non-stick-frying-pan/ES54102.html (accessed June 12, 2024).

[15] InGenious Lazy Man Frying Pan - Multiple Hob 5-in-1 Breakfast Cooking Skillet : Amazon.co.uk: Home & Kitchen, (n.d.). https://www.amazon.co.uk/dp/B072Y6C535?ref_=cm_sw_r_cp_ud_dp_PG56JJD3DSS662Z1MPM5 (accessed June 12, 2024).

[16] Tesco Basics Aluminium Frying Pan 24 Cm - Tesco Groceries, (n.d.). https://www.tesco.com/groceries/en-GB/products/299932096 (accessed June 12, 2024).

[17] TEFAL Ingenio Easy Cook & Clean 5 Piece L1549043, (n.d.). https://www.tefal.co.uk/c/Ingenio-Easy-Cook-%26-Clean-5-Piece/p/2100125952 (accessed June 12, 2024).

[18] Niels. Diffrient, A.R. Tilley, J.C. Bardagjy, Henry Dreyfuss Associates., Humanscale 1/2/3, (1974). https://books.google.com/books/about/Humanscale_1_2_3.html?hl=id&id=Wja2mAEACAAJ (accessed June 12, 2024).

[19] Humanscale 1/2/3 - Niels Diffrient, Alvin R. Tilley, Henry Dreyfuss Associates, Joan C. Bardagjy - Google Buku, (n.d.). https://books.google.co.id/books/about/Humanscale_1_2_3.html?id=Wja2mAEACAAJ&redir_esc=y (accessed June 12, 2024).