RESEARCH ARTICLE

Product Design Innovation for Enhancing Table Stability on Various Outdoor Surfaces

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Abstract

Tables in outdoor settings may encounter obstacles such as shifts, trembles, or inclines, mostly due to the differing characteristics of the materials used for the table legs' supports. Coffee shop enterprises often have this issue in their outdoor areas. Prior research and patents offer design solutions for uneven surfaces in typically flat rooms, resulting in permanent integration with the table leg, hence restricting its applicability to different table shapes. The study was conducted at multiple coffee shops utilizing design thinking methodology. The process commenced with an empathy phase to identify the issue, followed by direct trials on various exterior surfaces, leading to the formulation of product design concepts as solutions. This research seeks to provide an innovative product design for table furniture stability on diverse surfaces, including grass, sand, soil, and gravel. The findings suggest the design may potentially provide stability on various surfaces; however, it cannot be fully ensured due to the influence of surface material properties, which are susceptible to microclimates and weather variations. The proposed design solution serves as a reference for designers and the furniture industry aiming to manufacture it, potentially evolving into a modular furniture part for end users to augment practical applications.

Keywords: *Design, Product, Stability, Furniture, Table.*

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Introduction

Interior design facilitates daily human activities in spaces defined by roofs, walls, floors, doors, windows, stairs, and items that occupy space, including lighting, ventilation, utilities, circulation systems, and furniture (Ching & Binggeli, 2017). Due to its dynamic features, furniture stands out among various interior components, facilitating both direct and indirect interactions between space users and the furnishings. Another significant category is table furniture, which caters to a variety of activities such as work, dining, and both formal and informal gatherings. Table furniture is versatile, capable of fulfilling both formal and informal requirements, regardless of its indoor or outdoor placement.

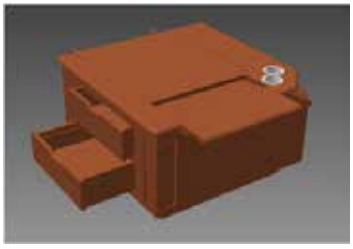
Following the subsidence of the COVID-19 pandemic, the community has developed a habit of working remotely. Students and employees frequently engage in assignments at nearby coffee shops, inadvertently altering the state of the furniture to suit their activities, including eating and drinking. Nevertheless, if

these conditions exist at an outdoor coffee shop table on a diverse surface, it may result in the table shifting, becoming unstable, or tilting during activities (Salendra, 2014).

One aspect of improving the sensory experience that produces a good impression of coffee shop visitors is conditioning comfortable tables and bench sets (Candra et al., 2022). This research aims to examine the quality of the interior elements of table furniture, specifically in outdoor coffee shop areas, with a particular focus on the stability of the table furniture against various surfaces such as grass, ground, sand, and gravel. Coffee shops often overlook these surfaces, despite the potential for stable furniture design to improve consumer comfort. The research also seeks to enhance facility quality, thereby improving the consumer's sensory experience.

This design research aims to enhance the functional component of table furniture to prioritize consumer comfort activities, thereby increasing consumer loyalty, broadening target demographics, and promoting business sustainability. The process might commence by improving the stability of outdoor table furniture on diverse dynamic surfaces such as grass, ground, sand, and gravel.

Table 1. Image of furniture review in previous research.

 Figure 1. e1027 table by Eileen gray Source: Wang & Dickerson, 2013	 Figure 2. Modern coffee table inspired by traditional Chinese lantern Source: Yin et al., 2021
 Figure 3. Smart coffee table appendix 5.1 Source: Owens, 2016	 Figure 4. Modern coffee table inspired by traditional Chinese lantern Source: Yin et al., 2021

Numerous studies have examined furniture in coffee cafes. Ergonomic furniture is an essential element of coffee shop design, considering the physical attributes that promote socialization and enrich experiences (Waxman, 2008). Additionally, Eileen Gray designed a coffee table that utilizes technology to adjust the table's surface height. This table features a chain and a pin for securing its height, optimizing its functionality on flat and hard surfaces (figure 1) (Wang & Dickerson, 2013). The coffee table's design is inspired by the Chinese lantern and offers substantial storage space on its surface. A hinge, which also functions as support for the table surface, enables it to elevate upwards. Lifting the table surface converts its underside into a practical storage space (figure 2) (Yin et al., 2021). The coffee table in a multifunctional design includes various features like trays, cup holders, and speakers, as illustrated in figure 3 (Owens, 2016). Coffee tables utilized in coffee shops typically possess several features, including robust construction, the application of dynamic concepts in both minimalist and maximalist styles, the

inclusion of drawers or storage compartments, user comfort, and environmentally sustainable, seawater-resistant, practical, and accessible designs. The Ergonomic Function Deployment (EFD) method generates the dimensions of the per-profile coffee table according to specified requirements: for a minimalist design, the dimensions are 70 cm in length, 70 cm in width, and 40 cm in height; for a maximalist design, the dimensions are 70 cm in length, 140 cm in width, and 40 cm in height (figure 4) (Novianti et al., 2015). These size specifications function as guidelines that can be modified for the design of coffee tables.

The design requirements for furniture must be adaptable to meet dynamic needs, as they significantly impact the concept of coffee shop environments, especially with impressions and experiences that affect consumer comfort. This differs from the assortment of traditional furniture utilized in coffee shops, not all of which can remain stable during user activities. Certain furniture can be efficiently utilized on flat or rigid surfaces. The instability issue arises from the furniture design, which requires modification to accommodate the surface contour of its placement, and is further compounded by mass production, which results in uniformity of the product's shape.

Upon reviewing the findings of prior studies concerning furniture characteristics, traditional furnishings, furniture implements, and market accessories, it is identified that certain furniture designs present innovations including adjustable table heights, rotatable table surfaces, versatility in materials and finishes, and furniture specifically engineered for outdoor use that is unsuitable for indoor environments, and vice versa. Based on these results, it can be concluded that the innovation is required in tools, specifically a design product that can be applied to each table leg to sustain the table according to diverse surface contours. This research will be presents significant prospects and possibilities for anyone aspiring to establish a coffee shop with diverse furnishings, mostly outdoor tables. This strategy can reduce expenses for both new and current coffee shops by obviating the necessity to acquire new furniture that matches the surface, thus maximizing the utility of existing furnishings. The ultimate effect of sustainability might enhance the comfort of guests engaging with the outdoor coffee shop table.

The research will focus on ways to ensure the stability of table furniture in outdoor environments with various surfaces, namely grass, ground, sand, and gravel. Product design will be developed as an innovation to stabilize outdoor tables in their sustainable phase, enhancing facility quality and consumer comfort for coffee shops requiring table stabilizer products.

Literature Review

Understanding design is a professional discipline that primarily emphasizes user requirements and inclinations, especially about human behavior and its underlying factors. Moreover, it is often seen that the ultimate design outcomes do not consistently fulfill the requirements of the end user. The design review process is conducted in response to consumer complaints and alerts regarding the design product. This method entails doing comprehensive and ongoing investigations of users' culture and daily routines to attain a precise assessment of furniture appropriateness (Siu, 2005).

Knowledge of furniture and its historical significance in the evolution of the interior design profession is essential for designers (Grimley & Mimi Love, 2013). Positively, we can persist in advancing furniture design through diverse creative discoveries alongside other scientific fields, with the objective of improving and positively impacting the appropriateness of human daily activities.

Construction and Technology Requirements

The assertions in this section were extracted from the book “Furniture Design” (Smardzewski, 2015). The stability of furniture is a prerequisite for various construction criteria, including fundamental concepts, efficient material utilization, rigidity, strength, and appropriate connection systems; the application of suitable technology in the manufacturing process; and the integration of technology within the furniture when necessary. These factors can influence the furniture’s characteristics, technical specifications, production expenses, and durability.

Moreover, throughout the furniture manufacturing process, it is essential to conduct analytical and numerical assessments to ascertain the strength of the furniture under static and dynamic loads prior to its utilization. The simulation process for multifunctional, movable, and morphing furniture employs a distinct methodology for assessing durability, with frequent evaluations conducted.

Utilizing technology in the production phase of conventional furniture types can improve efficiency regarding labor, time, and cost, facilitating the rapid mass production of furniture designs. This differs from custom-made furniture, indicating that, in this case, consumers own the authority to determine shape, function, construction, and technology. However, there are limitations concerning production length due to the necessity of specialized equipment and furniture experts for custom furniture fabrication, resulting in elevated manufacturing expenses. Despite being more expensive than conventional options, custom furniture holds unique value because it addresses specific issues and requires expertise to overcome the constraints of mass-produced furniture.

Table Furniture Equipment/Accessories Connection System

A connection system establishes links between each interconnected furniture component. A simple furniture system is essential to correspond with the furniture type, as it significantly affects its strength. The reliability, strength, and stiffness of the connection dictate the connection strength indication, ensuring the long-term durability of the furniture. Design that neglects the connection strength indicator can result in furniture being resistant to damage and lacking long-term durability. In these cases, furniture makers typically establish furniture guarantees (Smardzewski, 2015).

The primary elements of table design are the connection system, the tabletop, and the legs. A simple connection system utilizes a tenon and mortise joint, secured with pins and wood adhesive. This condition makes the shipping of goods impractical and inefficient, as they are prone to damage and require excessive space for delivery. This approach is most effective for furniture that is generally compact and does not necessitate considerable relocation post-manufacture. The knockdown furniture concept consolidates items into a compact package to reduce potential damage and improve the efficiency of the delivery process. The knockdown concept was established by linking each furniture component with specialized screws and connectors that facilitate assembly (Smardzewski, 2015).

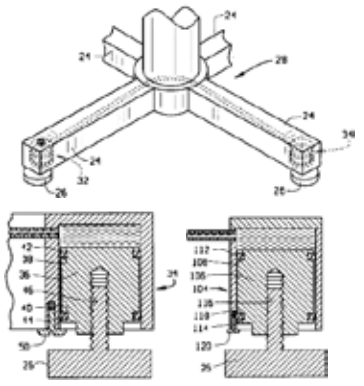
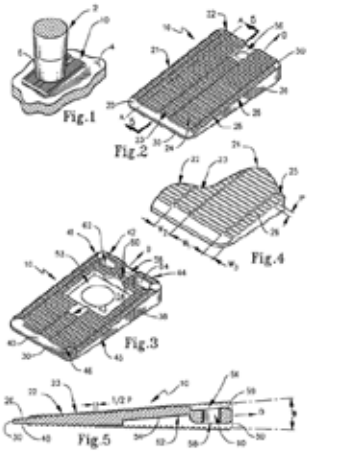
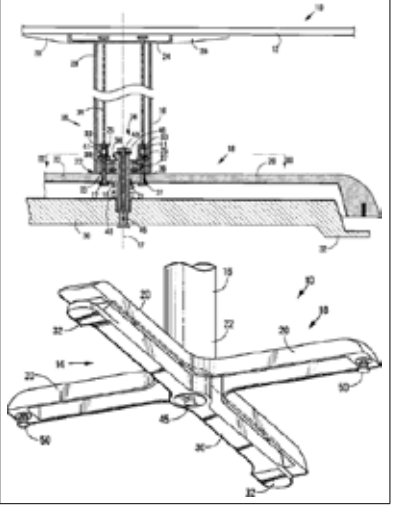
Mechanical furniture-connecting devices are always advancing in terms of their efficacy and efficiency. Generally, metal furniture uses bolts, nuts, and screws, while wooden furniture necessitates a material with elevated hardness and density to avert fracture (Smardzewski, 2015). The fundamental concept of a mechanical connection, involving the assembly of bolts with nuts and screws, adapts in size and substance to meet the specific requirements of a furniture mechanical connection. These improvements are evident in various furniture-connecting attachments, fulfilling multiple tasks and augmenting the practicality and functionality of the

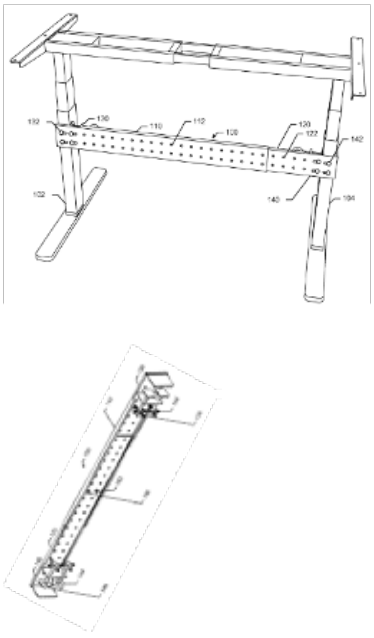
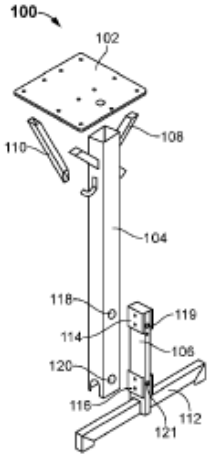
furniture. The concept of connection can use a linked system, screws, magnetic adhesion, adhesives, or knots utilizing rope, basic wooden joints, and other variations. Diverse initiatives have been undertaken to enhance furniture designs that address issues related to design, functionality, form, construction goals, technology, quality, aesthetics, economics, and efficiency.

Furniture Stabilizer patents.

A patent search was conducted on many discoveries related to table stability, including supplementary accessories like stabilizers, utilizing Google Patents with the keywords “furniture stability solutions” and “table stability mechanism.”

Table 2. Patent of Table Stabilizer.

No.	Patent Number	Title	Description	Patent Figure
1	US006009815A	Stabilized Table, Stabilizer for Tables, and Method of Stabilizing (Hartman, 1995)	A table featuring a distinctive stabilizing mechanism inhibits swaying on irregular surfaces. This method employs two interconnected fluid cylinders situated on the adjacent supports of the table. The pistons in each cylinder enable the table’s feet to move symmetrically and oppositely, facilitating adjustments for uneven flooring. This technology guarantees a stable surface irrespective of floor conditions by autonomously stabilizing the table without necessitating manual modifications. The design can be retrofitted into existing tables or incorporated into new ones.	
2	USOO7784751B1	Stabilizing Device, Along With Modular Configurations (Bellows & Mancino, 2008)	Stabilizing devices are designed to prevent objects like machinery or furniture from toppling, swaying, or vibrating on uneven surfaces. The robust, wedge-shaped structure and interlocking teeth on both the upper and lower sides allow for stacking or adjustment for stability. It encompasses cavities, notches, and optional magnetic or filler elements to enhance functionality, including vibration control, installation convenience, and compatibility with diverse applications. The instrument may be utilized independently or inside a modular system for the stabilization or leveling of items.	
3	USOO8876O71B2	Self-Stabilizing Support Assembly for an Item of Furniture (Brooke, 2010)	The support system self-stabilizes, ensuring that furniture, such as tables and chairs, remains stable on uneven surfaces. It possesses two pairs of feet—one stationary and one mobile—as components of a support framework. The technology autonomously distributes weight and stabilizes the furniture by connecting the movable feet to a guided pin that travels along an adjustable route. The frictional locking mechanism prevents slippage under stress, while the springs ensure proper foot positioning. This device facilitates the stabilization and leveling of furniture without necessitating manual adjustments.	

No.	Patent Number	Title	Description	Patent Figure
4	US20200260862A1	Desk Stabilizer Bar (Knapp & Meyer, 2019)	The stabilizing bar between two movable table legs consists of the following components: The stabilizing bar consists of the following components: (a) a first section with a first end and a second end; (b) a second segment with a first end and a second end, where the first end at least partially overlaps the second end of the first segment; (c) a mounting mechanism for positioning the second segment around the first segment; (d) a first clamping section at the first end of the first segment for reattaching the first segment to the first piece of furniture; and (e) a second clamping section at the second end of the second segment for reattaching the second segment to the second piece of furniture.	
5	WO2021026138A1	Locking Device and Stabilizer for a Stabilizing Table (Gierry, 2020)	This invention discloses a table with a primary and secondary shaft stabilizing mechanism. The primary shaft features a cutout at the bottom, a locking hole in the lower section, and a stabilizing mounting hole in the upper section. Once the secondary shaft is inserted into the primary shaft and has matching locking and stabilization mounting holes, it can be movably linked to the primary shaft via a pivot at the stabilization holes, enabling single-point movement. A locking mechanism that secures the secondary shaft to the primary shaft guarantees stability and controlled motion.	

The search for several patents on stabilizer furniture revealed that all inventions provide solutions for furniture or tables placed on indoor floors, which prefer floor materials with flat surfaces. Mechanically speaking, it offers answers to the issue of uneven floors brought on by variations in height on each supported table leg. Furthermore, the innovation's incorporation into a single furniture piece renders it inapplicable to other furniture goods. This research differs from previous research and patents in that it produces an innovative product design solution for outdoor table leg stabilizers with a variety of surface material characteristics. These stabilizers are flexible because they can adapt to various types of furniture or table legs. The idea resulting from this research is eventually a novelty that can be patented and further investigated for future production, which would benefit coffee shop owners by ensuring that furniture, especially tables, is stable when placed outdoors.

Research Method

Research Design

The research process employs a design thinking approach, specifically a problem-solving initiative, which begins with empathizing with the problem entity, its users, and the surrounding environment to identify the various problems that arise. After identifying alternative designs to address issues, we create prototypes for testing and evaluation of the selected designs until production and then periodically monitor the effectiveness of the design product in problem resolution (Wolniak, 2017). In this research process, each phase of design thinking employs a methodology that produces outputs, serving as guidelines for subsequent processes until the attainment of a solution (see Figure 5). This research represents the initial phase, which involves empathizing, defining, and ideating, leading to an innovative solution in the form of a table stabilizer for diverse outdoor surfaces. The afterwards phase, specifically prototype, product testing, and manufacturing, is further investigation that is not included in this research; it is conducted independently as it is primarily oriented at generating innovation product design as a result.

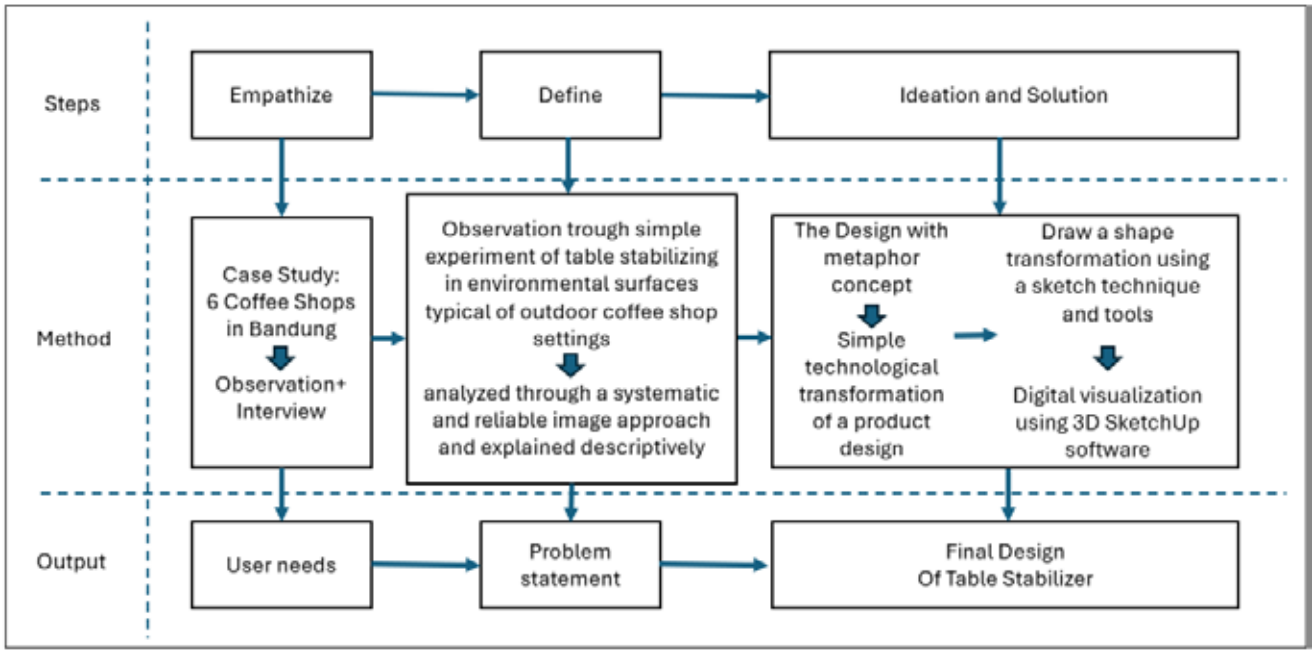


Figure 5. The Flowchart of Research Method with Design Thinking Approach

Source: Authors figure.

Empathize

On this stage, data was collected using the observation technique with purposive sampling among six coffee establishments in Bandung, Indonesia: Mokopi Café, Masagi Koffe, Mare Fruit Club, Lotu Coffee Eatery, Sejiwa Coffee, and Sun Date Moon Restaurant Café and Bar. The selection of coffee shops is deemed highly representative of this research need due to their diverse outdoor environments, including various surface kinds. Outdoor furniture typically features a uniform design characterized by vertically elongated legs. Furniture designs featuring this style of leg are most common and are often constrained by balance when placed outdoors (Figure 7). Observations were conducted at each coffee shop about the environment, the surfaces, and the materials supporting outdoor table furniture to stand on.

In addition, the empathize stage aims to collect data on the desires and preferences of users from both the coffee shop owner and the consumers through interviews. Respondents were selected depending on field observations of consumers exhibiting discomfort when utilizing tables in the outside area due to their instability. Interviews were conducted with three consumers at each of the selected coffee shops designated as case studies. The interview focused on consumer activities and interactions with the table, a facility offered by the coffee shop, in relation to comfort impacted by table stability. The interview data was descriptively processed and analyzed.

Define

Following the acquisition of data and output during the empathize stage, observations were conducted at the define stage on the stability of the table, contingent upon the sort of exterior surface present in the six coffee shops. We conducted observations on outdoor tables made of diverse materials, subjecting them to the typical activities of coffee shop customers. These activities included resting hands on the tables and applying a relevant load representative of the average weight of items, such as a few cups of coffee, snacks on plates, laptops, mobile phones, and tote bags.

Multiple phases of simple experiments are conducted in simulation to investigate the causes and effects of table leg stability in the exterior area of the coffee shop. The initial step involves identifying a comparable site, including the same surface materials, specifically grass, sand, dirt, and gravel. Subsequently, the selection of a table design is required, characterized by elongated and vertical legs on several sides. A table featuring a folding mechanism was selected due to its portability and ease of relocation. Subsequently, identify the activity of various consumer interactions, namely supporting hands, utilizing a laptop, and imitating the arrangement of items often seen on a table (Figure 6). Selecting a cast that represents the physical condition of consumers in general, such as adults with an ideal height and weight. When all is fulfilled, then the simple experiment is carried out in each predetermined location.

Figure 6. (a) an example of one of the selected locations, (b) the table used in the simple experiment, (c) the arrangement of consumer items, (d) an example of one of the interaction positions

Source: Authors figure.

At this stage, data is collected concerning the variants of the outdoor materials of the coffee shop and what characteristics of these materials contribute to the instability and unevenness of the tables during consumer use. The observed parameters include the conditions before and after the simple experimental simulation, assessing any shifts, tilts due to imbalance, or sways during usage. Subsequently, observations are conducted on the table legs to analyze the conditions and changes, thereby elucidating the properties and characteristics of surface materials that influence instability, which will later inform the ideation and solution phases. Analyzed through a systematic and reliable image approach and explained descriptively. A systematic review involves comprehensive search, critical assessment, and synthesis of all pertinent studies on a specific topic,

particularly relevant for evaluating diagnostic studies and screening images of documentation results. The analysis could involve qualitative, quantitative, or a meta-analysis (Cronin, et.al, 2018).

Ideation and Solution

The ideation and solution stage emphasizes enhancing the quality of facilities and the stability of furniture, specifically outdoor tables placed on various surface materials. The product design exploration approach employs metaphor through the simple technological adaptation of current product designs. Reference enrichment is conducted by internet searching and analysis, in addition to direct observation of market products. The selected products utilize straightforward technologies and include designs pertinent to the research objectives in identifying remedies. Moreover, the design reference evolves into the idea for the development of a shape utilized in a table stabilizer product design that may be affixed to the table leg. The shape development process is executed using the transformation method utilizing drawing techniques with digital tools, including tablets and digital pens in conjunction with the sketchbook application.

The process leading to the final design, which focuses on the stability of outdoor coffee shop tables, involves digitally visualizing the resultant shape and design concepts in three dimensions using SketchUp software in a measurable and scalable manner based on field observations. This final design will thereafter be used to conduct further research, culminating in a prototype, wherein the research emphasizes testing and refining the design to adapt to actual conditions throughout field implementation until it evolves into an effective product.

Findings And Results

The Observation (Empathize Stage)

The six observed coffee shops used various surface materials for their outdoor tables and chairs. Each surface has different characteristics that impact the stability of the furniture placed upon it. The existing surfaces consisted of the ground, grass, sand, and gravel. Some areas feature paving blocks and concrete floors, which generally exhibit greater flatness and stability compared to other surfaces (Figure 7). Gravel surfaces are consistently found in every outdoor area in the coffee shop; also, outdoor spaces having grass and ground surfaces are found in most coffee shops (Table 3). Consumers, who also use furniture, agreed in the interview that the table's instability makes it uncomfortable for usage. After conducting interviews with various customers of coffee shops, the owners expressed a desire to enhance the quality of their customer service by implementing solutions to stabilize outdoor tables, thereby enhancing comfort without the need for replacement furnishings. Initially, they merely anticipated that the outdoor furniture should maintain its strength and durability in the face of fluctuating weather conditions.

Table 3. Material Surface of Each Outdoor Area Coffee Shop

Outdoor area location/material surface	Grass	Ground	Sand	Gravel	Paving block/concrete
Mokopi Café				**V**	**V**
Masagi Koffe	**V**	**V**		**V**	**V**
Mare Fruit Club			**V**	**V**	
Lotu Coffee Eatery	**V**	**V**		**V**	**V**
Sejiwa Coffee	**V**	**V**		**V**	**V**
Sun Date Moon Café			**V**		**V**

Each coffee shop has its various table designs, with the legs not intended to be compatible with various surface materials. Whether round or square, the legs typically share similar characteristics, elongating and providing support at the corners along the tabletop's underside to ensure stability. However, this does not impact their functionality (Figure 7). That condition provides a versatile and functional design challenge, as the table legs exhibit the same characteristics but different shape and dimension.

Figure 7. Sample Table Conditions with Various Uneven Outdoor Surfaces at Selected Coffe Shop

Source: Authors figure.

Table Stability on Various Surfaces (Define Stage)

Coffee shops have four varieties of outdoor surfaces: grass, the ground, sand, and gravel, each possessing distinct material characteristics that affect the stability of tables when used by customers. Upon examining the table situated on each of these surfaces and subjecting them to identical conditions. Analysis of image documentation indicates that all tables appear stable and do not exhibit characteristics of instability or sloping surfaces. However, direct observation reveals that, despite the tables appearing stable, they are positioned on surfaces that are not entirely flat, as the legs do not maintain uniform height or parallel alignment; in some instances, one leg is not fully grounded. This condition arises from irregular surfaces and differing material hardness at each point of contact for the table legs, attributable to the pressure exerted by the table load itself (Figure 8).

Customer activity and the application of appropriate loads during usage, it exhibits instability resulting in the table surface tilting, swaying, or the legs piercing the surface. Observations from the existing indicate that the interaction between the user and the table surface predominantly happens along the edges. The interaction typically involves actions that exert weight pressure, resulting in downward force. This observation aligns with the findings of the analysis of the observed image of experiment documentation. This pressure condition compels the foot on that side to constructively support, yet the varying hardness of each particle or component of the surface results in downward pressure, thereby affecting the non-parallel alteration in the height of the footrest (Figure 9). The experiment involving the arrangement of consumer products on a table demonstrates that the positioning, weight, size, and kind of goods significantly influence the uneven downward pressure exerted on each table leg, hence affecting the impact on the surface material of each footstep.

Figure 8. Table conditions on various surface

Source: Authors figure.

Under conditions where the sand media is neither sufficiently soft nor moist, potentially influenced by the rainy season, user activities on the table, and the application of weight on the table surface, the table's condition appears stable in the short term. However, prolonged use, especially when multiple individuals engage in activities on the table and the surfaces are moist to wet, may influence stability. The table's standing becomes unstable.

Likewise, on a grass footing surface, the presence of grass does not markedly improve the stability of the table, especially when the ground is moist, and the user uses a table of a particular weight. Nevertheless, if the grass on the ground or sand is dry, the table will tend to remain stable over time due to the dense grass supporting it.

Placing a table on the sand and subjecting it to a specific weight over an extended period will entrench the table's legs in the sand, causing instability due to varying depths of piercing for each leg. Whether the sand is moist or wet, the cohesion of the grains will alter its density, resulting in the table legs being less embedded compared to dry sand, but remaining unstable.

The gravel surface remains unaffected by wet or dry circumstances due to the hardness of the footing medium. The rigid nature is further exacerbated by the varying sizes and shapes of the pebbles, resulting in suboptimal contact with the table legs, which leads to instability that becomes apparent during active use and when weight is applied to the table surface.

Figure 9. Condition of each table when in use and when under load on (1) grass, (2) ground, (3) sand, (4) gravel

Source: Authors figure.

The investigation of the table's instability during user interaction and under load conditions revealed that certain footing media conditions, both in the short term and long term, can directly cause the table to become unstable.

On a dry surface, the condition of the table legs gets inside in the under surface especially ground and the sand. stability may arise if the hardness of the ground and sand beneath each table leg varies, leading to unevenness among the legs. Wet footing conditions exacerbate this instability, as some or all table legs may penetrate deeper into the under surface, altering the table surface's height and compromising user comfort due to instability (Figure 10).

Figure 10. The condition of each surface under table leg after use and given loads, (1) ground, (2) grass, (3) sand, and (4) gravel

Source: Authors figure.

The grassy footing surface tend to the softness of the ground and sand footing surface, as the grass acts as a cushion for the table legs, preventing direct contact with the ground. The image documentation of the experiment (figure 10.2) shows that the table legs exert an impact on the grass, resulting in significantly deformation, they do not penetrate the soil surface due to its hardness. In contrast, if the soil were soft, the table legs might penetrate the underlying soil layer beneath the grass. Consequently, when the grassy surface is wet, it poses minimal issues. However, to prevent instability when using and loading the table with weight, it is crucial to ensure uniform grass thickness across the entire table legs steps.

Wet or dry conditions do not affect the instability issue, which arises directly on the surface of the gravel stones. The varying sizes and shapes of the gravel stones result in uneven footing conditions for the table, leading to immediate instability. Adjusting all table legs to contact the ground beneath the gravel achieves stability. The experimental documentation photograph (figure 10.4) illustrates that the pebbles beneath the table legs are displaced from the region subjected to pressure from above. Likewise, the surface of the soil (figure 10.1) and sand (figure 10.3) indicates a displacement of sand and soil particles around the table legs during footing. This situation arises from the height adjustment of each table leg to stabilize the footing at the point where each leg contacts the most rigid surface layer. However, after a specific duration, the instability issue will resurface and manifest on the ground surface; additionally, users will find it cumbersome and impractical to adjust the table legs to ensure stability during activities with some loads. The review of the table's stability conditions, considering long-term usage under not treated, given treatment, and burdening, can be summarized in the following table:

Table 4. The Results of The Conclusion of The Stability Conditions of The Table on Each Surface When Activity Occurs, and a Load is Applied

Material surface	Footing surface character	Not treated	Given treatment	Given a burden	Final description of table stability
Ground	Tend to be soft	stable	unstable	unstable	unstable
Grass	Tends to be tough	stable	unstable	unstable	unstable
Sand	Easy to decompose	stable	unstable	unstable	unstable
Gravel	Very hard and varied	unstable	unstable	unstable	unstable

The results of Table 4 indicates that the entire surface of the table stepping material generates unstable situations, necessitating a product design innovation to ensure stability on each compact and practical table surface in accordance with the specific criteria of the base material surface. The subsequent phase of the ideation process uses metaphor to transform the shape of the existing design product based on the type of surface (ground, grass, sand, and gravel). The chosen product designs utilized as references are founded on straightforward technology that offers solutions similar to the requirements of table leg stabilizers on various surfaces.

The Product Design Exploration (Ideate and Solution Stage)

At this stage, the process relies on creative thinking; specifically, creative thinking is a systematic yet flexible method of examining certain problems or circumstances from diverse perspectives and analyzing them through numerous techniques to generate innovative ideas or solutions. (Gafour & Gafour, 2020). Graciela & Damayanti (2021) apply a metaphorical approach to the creative thinking process, transposing metaphors from descriptions onto disparate objects to accurately apply analogies. This research applies a metaphorical creative thinking process to existing design products to understand their functional value in relation to the materials of the environment that interact with the design product. This process enables the subsequent adjustment of the value to the table stabilizer design across various surfaces.

a. The Design of a Table Stabilizer Connector with a Table Leg

Before designing a table stabilizer for diverse surface variations, it is crucial to consider the coffee shop owner's desire to avoid replacing outdoor furniture. The solution must be in the form of an innovative, flexible table stabilizer product that is capable of being installed on similar table legs despite their different shapes or designs. In response to this requirement, the proposed solution is a flexible connector designed for elongated forms of table legs. This connector serves as a means to attach a flexible table stabilizer, which can be installed or removed to accommodate in accordance with the type of outdoor surface on which the table is placed. The connector's design is inspired by the gripping form of an octopus tentacle, which is utilized in a lamp replacement stick (Figure 11).

Figure 11. Lamp Replacement Stick

Source: https://www.blibli.com/p/stik-tongkat-pengganti-bohlam-lampu-nagata-2-7-meter-ngt-2001/ps--PTJ-70027-38652

This form is designed to be adaptable and can grip table legs of differing dimensions as well as square or rounded shapes, comprising two materials: plastic and a spring bracelet that can adjust to the shape of the table leg. A threaded connector system, like that of a drinking bottle and its cap, is employed at the base as a linkage mechanism with a table stabilizer, allowing for flexible adjustment to the condition and materials of surfaces. The design commences with the transformation of the clamp head shape of the lamp replacement stick through sketching, followed by three-dimensional visualization to aid in shape development, and culminates in the creation of a dummy for trying practical application on a table leg (Figure 12).

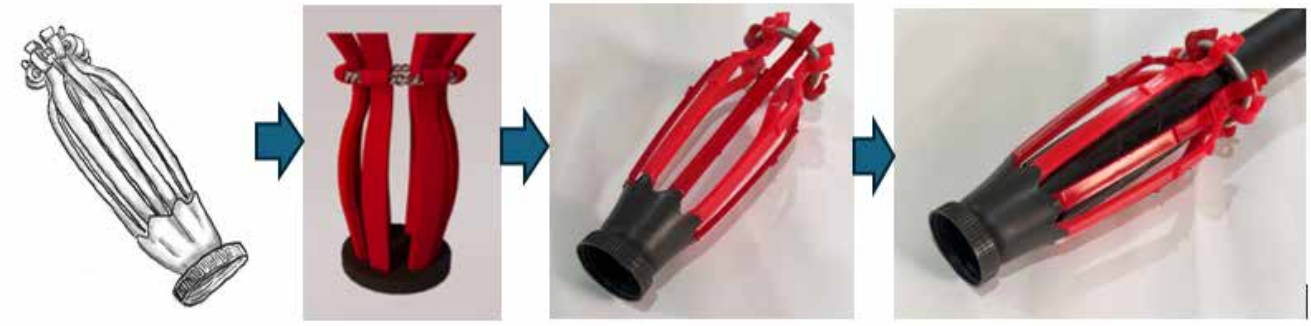


Figure 12. Table stabilizer connector design step outcomes

Source: Authors figure.

b. The Design of a Table Stabilizer on The Grass Surface

The design of grip spikes on the soles of golf shoes enhances a golfer's stability during swings, ensuring they maintain their intended posture and preventing slippage (Figure 13). The spike mechanism is integrated into a table stabilizer design for the grass tread surface, ensuring prolonged stability of the load during table usage.

Figure 13. Golf shoes spikes

Source: https://www.adidas.com.au/blog/627764-spikes-vs-spikeless-golf-shoes-which-is-best-for-you

The metaphorical process is the integration of golf shoe spikes into a grass platform table stabilizer constructed from lightweight and durable aluminum, complemented by a supporting component made of plastic. The design commences with the transformation of the golf shoe spikes through sketching, followed by three-dimensional visualization to aid in shape development, and culminates in the creation of a dummy for trying practical application on a table leg connected with stabilizer connectors. (Figure 14).

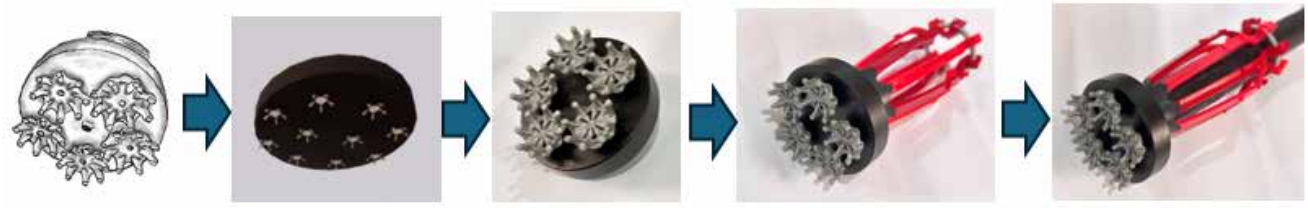


Figure 14. Table Stabilizer on The Grass Surface design step outcomes

Source: Authors Figure.

c. The Design of a Table Stabilizer on The Ground Surface

The concept features a pointed implement analogous to a nail at the base of the trekking pole, which enhances the climber's stability by anchoring it into the ground, ensuring a balanced and stable ascent (Figure 15). Consequently, the notion of nails is integrated into a table stabilizer design for the ground surface, ensuring stability during placement and usage.

Figure 15. Trekking Pole

Source: https://phinemo.com/rekomendasi-trekking-pole-untuk-pendaki/trekking-pole-6/

The metaphorical process involves the transformation of trekking pole nails, which are anchored to the ground surface stabilizer, using lightweight and sturdy aluminum materials, complemented by bowl-shaped supports made of plastic. The design commences with the transformation of the trekking pole through sketching, followed by three-dimensional visualization to aid in shape development, and culminates in the creation of a dummy for trying practical application on a table leg connected with stabilizer connectors (Figure 16).

Figure 16. Table Stabilizer Design on The Ground Surface design step outcomes

Source: Authors figure.

d. The design of a Table Stabilizer on The Sand Surface

A traction board serves as a platform or step to aid a vehicle immobilized in mud, snow, or sand. The surface of a traction board resembles a shoe's outsole, providing grip on various terrains for both footwear and car tires navigating through mud, snow, and sand (Figure 17). Therefore, a simple technology concerning the configuration of the traction board surface is integrated into a table stabilizer designed for a sand-stepping surface, ensuring stability during prolonged usage and loads.

Figure 17. Traction Board

Source: https://arbusa.com/recovery/tred/

The metaphorical process of the traction board shapes is integrated into a table stabilizer constructed from aluminum, which offers the benefits of being lightweight, durable, and bowl-shaped, complemented by a plastic support. The design commences with the transformation of the traction board through sketching, followed by three-dimensional visualization to aid in shape development, and culminates in the creation of a dummy for trying practical application on a table leg connected with stabilizer connectors (Figure 18).

Figure 18. Table Stabilizer Design on The Sand Surface design step outcomes

Source: Authors Figure.

e. The Design of a Table Stabilizer on The Gravel Surface

Gravel stabilizer grids are used to reinforce the gravel surface, preventing displacement when subjected to dynamic loads. Typically, coffee shops with gravel surfaces in their outdoor areas are not using gravel grids (Figure 19). To stabilize the table above gravel, this idea is inverted by applying an adaptation of the gravel grid shape to the table stabilizer, ensuring that the table remains stable for a long time when positioned on the gravel surface.

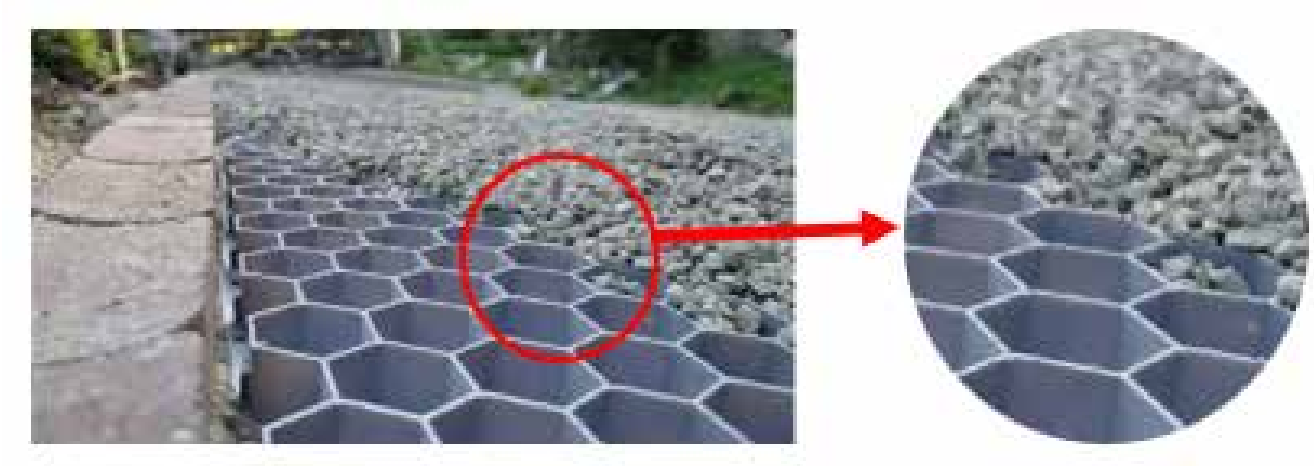


Figure 19. Gravel Stabilizer

Source: https://diy.stackexchange.com/questions/85778/is-this-gravel-stabilizing-underlament-an-effective-product

The metaphorical process of the gravel grid stabilizer is integrated into a gravel table stabilizer constructed from polyvinyl chloride (PVC) plastic, which offers the benefits of being lightweight and durable. The design commences with the transformation of the gravel stabilizer through sketching, followed by three-dimensional visualization to aid in shape development, and culminates in the creation of a dummy for trying practical application on a table leg connected with stabilizer connectors (Figure 20).

Figure 20. Table stabilizer design on the gravel surface design step outcomes

Source: Authors figure.

Discussion

The uneven surface of the coffee shop renders the furniture used by customers unsteady. The interaction between the user and the table surface primarily occurs at the edges. This interaction typically involves actions that apply weight, leading to downward force. This pressure causes the foot on that side to provide support, but the varying hardness of each surface particle or component creates uneven downward pressure, affecting the height variation of the footrest. The arrangement of items on a table such as their positioning, weight, size, and type significantly influences the uneven downward pressure on each table leg, thereby affecting the impact on the surface material beneath each footstep. This condition creates discomfort in consumers during usage, occasionally causing tilting or swaying. Each surface possesses different characteristics and textures, making it infeasible to offer furniture design solutions that accommodate the requirements of each surface type. Its outdoor presence also influences the level of surface hardness when supporting the table. Changes in weather conditions can rapidly affect surface materials; for instance, during the rainy season, outdoor surfaces become wetter and softer, resulting in increased instability of the table. This research provides a method through product design innovation that can enhance table stability based on the surface type on which it is positioned. Designed with adaptability, it can conform to the dimensions and contours of table legs and cater to various surface requirements through a knockdown system.

This innovative table-stabilizing product design accommodates only four surface types: grass, dirt, sand, and gravel. This refers to the overall outdoor surface conditions at the coffee shop. The stabilizer is positioned on the table legs due to their direct contact with the uneven surface. The use of metaphorical concepts through a transformation of existing product design using simple technology aims at solving the problems of table stability on various surfaces.

The current patent search indicates that innovations in furniture stability predominantly focus on settings with smooth, level surfaces. It is Similar to previous studies on indoor coffee tables. This research provides innovative and novel findings that enhance the stability of outdoor furniture, particularly tables, across various surfaces. The design of the table stabilization product is versatile, allowing for removal and installation on various table types with similar leg structures, namely elongated, and adaptable to different surface conditions such as grass, ground, sand, or gravel. The findings of this research can progress to the subsequent phase by formulating a design through an implementative methodology, following to the further stages of the design thinking framework, specifically by creating a real-scale prototype and subsequently conducting testing phases to evaluate the design's effectiveness, thereby enabling further development and refinement that results in a final product suitable for production and application.

Conclusion

The quality of service provided to consumers at coffee shops extends beyond merely evaluating the quality of coffee products. It is essential to evaluate the condition of the store environment and the facilities that facilitate activities during the enjoyment of coffee, including the furnishings. Unstable furniture, due to its outside placement and uneven surface, can significantly impact customer comfort during usage. The outdoor area of the six coffee shops typically consists of four materials: grass, ground, sand, and gravel, each having different characteristics that require a designed table stabilizing design. To provide flexibility within the product design unit, the concept of a connector design linking the table stabilizer and the table legs serves as a solution, as it can be easily removed and installed to accommodate the specific surface type on which the table stands. This connector was designed for flexibility, allowing for adjustments in the shape and size of the table legs. The

implementation of the metaphor notion, which involves transforming the form of an existing product design, is essential for generating improvements in table design stabilization. The design created has the potential to provide stability for tables on various surfaces; however, this stability cannot be fully assured due to the influence of surface material types and characteristics, which can be affected by microclimates and weather changes. The suggested design approach can serve as a reference for designers and the furniture industry aiming to create modular components that enhance the stability of existing outdoor furniture, which can then be further developed into modular furniture pieces to improve practical use for end users. However, the extent of design success remains unmeasured. This research primarily results in a product design; hence, further research is necessary to develop a prototype, enabling the testing and refinement of the design to create a viable and functional product.

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