



Designing “MULTI-FUNCTIONAL FOLDABLE FURNITURE IN SMALL SPACE” Smart. Space-Saving. Stylish Furniture.

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Abstract: As urban living spaces become more constricted and the demand for housing increases, there is a growing need for furniture to be efficient, compact, and multifunctional. This research examines foldable multifunctional furniture design as a way to efficiently use limited space within living units, specifically micro-units. The study utilizes a design-led method, and analyzes and presents real-world prototypes, in the case of a notable collaboration between Stephen Kenn and Victorinox. The prototypes included a chair that also acts as a stepladder, a desk that also acts as a coffee table, as well as a modular cabinet that incorporates mirrored surfaces. These prototypes act as examples of savings in space, which consider functionality and, aesthetic integrity. A cost analysis relating to materials, production, and long-term durability helps to show the practicality of this furniture for urban users. While some examples showed luxury design, this paper also discusses ways the principles can be scaled for consumption at lower entry point values. Overall, the findings indicate that multifunctional foldable furniture is not only an answer to the problem of limited spaces for users, it could become the model for a new modern urban living style. Future research is required to measure and quantify the full extent of the impact that this will have on our cost and property management systems, but the full contribution to the quality of the user experience should also be acknowledged.

[Key words: limited space, multifunctional furniture, foldable furniture, micro-units, space saving, design-led method, prototypes, cost analysis, scalability, urban users, small living environments, open-concept layouts]

I. INTRODUCTION

Functional analysis is the most crucial aspect of space allocation. Graphically illustrating the use of space helps understand its design. Homes typically have social, work, private, and storage zones with functional interrelationships. For example, kitchens are often near dining areas, and bedrooms are grouped around bathrooms. Modern homes may feature overlapping zones like kitchen-diners. Effective space planning recognizes these interrelationships, ensuring activities flow smoothly between zones.

Micro-units, small apartments (200-400 sq ft), are gaining popularity in urban areas due to urbanization, rising housing costs, a shift towards minimalism, and changing lifestyles prioritizing experiences over possessions. They offer cost efficiency, convenient locations, community living, and reduced maintenance. However, challenges include limited space, potential unsuitability for long-term living or families, and privacy concerns. The future of micro-units looks promising as cities face housing shortages, with innovative designs and smart

home technology potentially enhancing their appeal and functionality. This trend may also inspire broader cultural shifts towards valuing less space and fewer material possessions.^[2]



Multi-functional furniture serves more than one purpose, offering flexibility to adapt to different needs and spaces. As modern homes embrace open-concept layouts, rooms are becoming more dynamic, requiring furniture that can easily shift functions. For example, living rooms can serve as entertainment areas, family spaces, or formal sitting rooms depending on the occasion. Multi-functional furniture enables quick layout changes, optimizing space and accommodating extra people. Some pieces, like swivel chairs, may appear to have a single function but still enhance flexibility by allowing easy repositioning.

The increasing relevance of multifunctional foldable furniture in optimizing living spaces, especially considering the growth of urban living and the reduction in apartment sizes, forms the basis of inquiry for this paper. The central question explored is how effectively multifunctional foldable furniture contributes to space optimization and enhances the quality of life within small living environments. The paper aims to investigate the design principles, analyze the practical applications, and evaluate the impact of such furniture on maximizing space utilization and improving functionality within compact dwellings. By examining existing research and examples, the study intends to highlight the importance of multifunctional foldable furniture as a viable solution for addressing the challenges posed by limited living areas and fostering comfortable, efficient living.^[3]

LITERATURE REVIEW :

Patricia J. Hernecheck et al. (1983) on entry-level interior design competencies highlighted the importance of furniture arrangement and space planning as key technical skills.^[4]

Nomoto et al. (1995) explored a kitchen planning system using virtual reality, emphasizing the design of kitchen layouts and the collection of information based on consumer lifestyles, indirectly relating to efficient space utilization in a specific room.^[5]

Zeyangi et al. (2008) developed an interactive system based on interior design guidelines for furniture layout, where users could specify room shapes and furniture sets and interactively arrange pieces, addressing the challenge of optimizing furniture placement within a given space.^[6]

Tantawy et al. (2015) presented guidelines for furniture layout in interior design, emphasizing techniques for creating desirable layouts while considering practical and design factors. The study analyzed criteria for effective furniture layout in living rooms and spaces, including room measurements and convenient layouts for different room shapes.^{[7][8]}

Dr. Diaaelden Mohamed Amin Tantawy et al. (2015) also studied guidelines for furniture layout, highlighting the designer's responsibility to create functional, comfortable, and pleasant spaces, especially in apartments where residents spend significant time. The research emphasized the importance of free space and analyzed criteria for effective layout, including space availability and cost-effectiveness.^[9]

Wang Qian et al. (2018) analyzed interior space design and visual artistic effects, noting that interior design establishes a relationship between space and people, addressing their behavioral and psychological needs. The paper discussed the principles of interior space design, considering both practicality and visual perception.^{[10][11]}

Ahana Sarkar et al. (2019) optimized the interior design for a naturally ventilated low-income resettlement unit, focusing on improved indoor environmental experience and maximizing natural ventilation. The study explored the optimal placement of partition walls, cook-stoves, and beds to enhance airflow and overall environmental quality within the unit.^[12]

Shawn M. Falcone et al. (2019) examined the positive impact of interior design on new home value, specifically looking at the influence of designers' expertise in space planning, including layout, function, room utilization, and furniture arrangement.^[13]

Amir et al. (2019) analyzed the role of interior design details in the perception of house spaciousness, confirming that design elements like shape, size, color, and light can alter how spacious interior spaces are perceived. The research stressed the importance of using design instruments to create a feeling of spaciousness, considering how inhabitants perceive a space based on various factors.^[14]

AIM: The aim of this research paper is to explore how multifunctional foldable furniture can serve as a practical and efficient solution to the growing problem of limited space in urban micro-units. The research seeks to investigate how such furniture can optimize small living environments by combining design innovation, cost-efficiency, and space adaptability, while still maintaining aesthetic value. The study does this through a design-led approach, using real-world prototypes (such as those developed by Stephen Kenn in collaboration with Victorinox) as case studies.

Research Question: *“How effectively does multifunctional foldable furniture contribute to space optimization and enhance the quality of life within compact urban living environments?”*

The question directs the research into:

The aesthetic principles of multifunctional furniture's

The functional advantages of space efficiency and versatility,

The financial viability, by a comprehensive cost breakdown of materials, manufacturing, and long-term wear,

And the scalability of such furniture solutions for broader urban adoption beyond high-end markets.

METHODOLOGY : This research adopts a design-driven approach to investigate innovative, space-saving, and cost-efficient furniture solutions for compact urban living. The study focuses on the development and testing of multifunctional furniture prototypes inspired by real-life constraints and creative ideation processes.

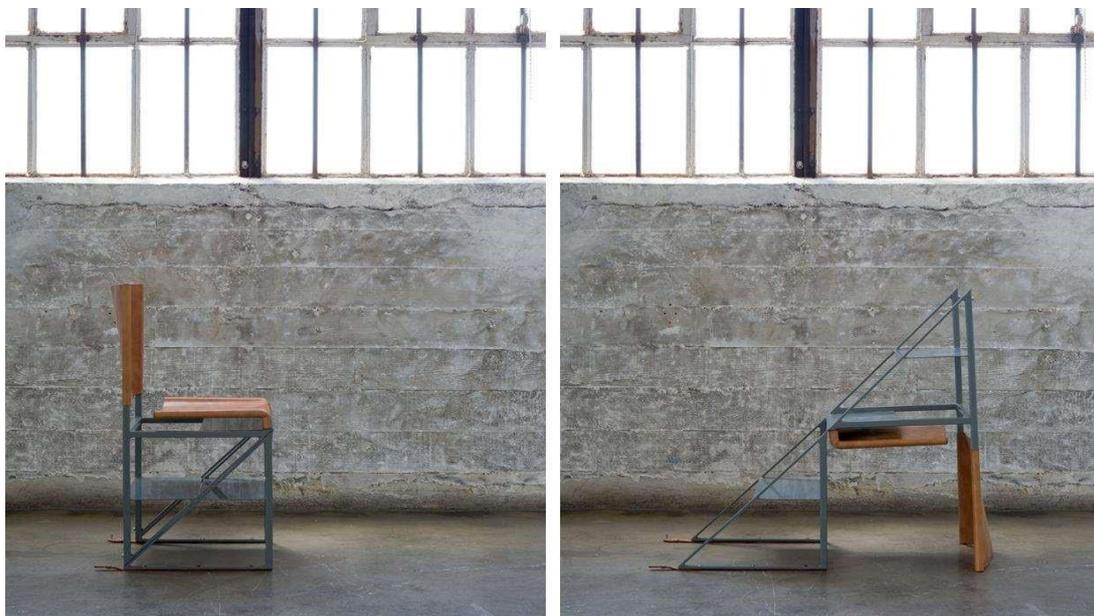


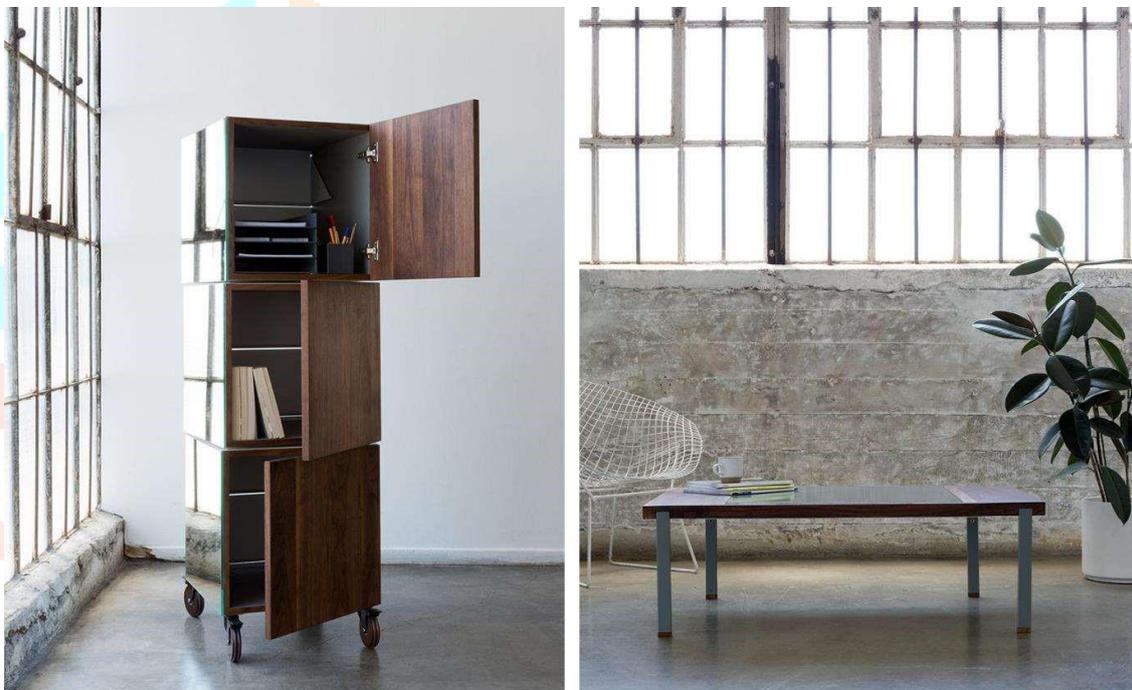
Kenn was inspired by the compact multi-functionality of the traditional pen-knife in his trio of designs (Image credit: StephenKenn)

A collection of design prototypes was curated, each addressing space optimization through dual-purpose functionality. These included:

- A seat that doubles as a step-ladder,
- A desk convertible into a coffee table, and
- A modular cabinet that rotates into a full-length mirror.

These pieces were developed iteratively, using a challenge-based framework where each design began with a specific spatial or functional problem and aimed to resolve it with a single, versatile solution. The designs were created by an individual designer (Ken), who approached the brief with the mindset of a problem-solver. Viewing the constraints of the project as an opportunity for innovation, he returned with fully realized prototypes that blended practicality with visual appeal.





Pictured left: the reverse of the mirrored cabinet, which features roomy storage boxes. Right: the convertible desk in coffee table form (Image credit: Stephen Kenn)

One notable innovation involved rethinking height adjustment mechanisms. Instead of employing conventional telescoping systems, the designer was inspired by the Swiss army knife's toothpick and tweezer design. This led to the development of removable, insertable legs that enable adjustable table heights. This solution offered both functional flexibility and a seamless integration into the aesthetic and structural design of the table.

Additional prototypes included:

- A multifunctional chair that transforms into a ladder,
- A cabinet that doubles as a full-size mirror,
- A reimagined sofa that was dismantled and redesigned into a completely new piece of furniture.

While highly functional, the final products maintained a distinct material character. For instance, leather detailing with exposed stitching added a rustic sensibility to the multifunctional chair, while industrial casters provided mobility and a raw aesthetic to the modular cabinet.

Throughout the process, the emphasis remained on cost-efficiency, material reuse, and space adaptability. The prototypes were analyzed based on their ability to transform, structural integrity, material economy, and ability to integrate into compact living spaces. The outcomes of this design-led research contribute to the growing field of adaptable furniture solutions for urban environments.

The Stephen Kenn and Victorinox collaboration showcases space-saving design for urban living. Their furniture features clever transformations, like a chair to a stepladder and a desk to a coffee table. A rotating storage column offers multiple functions. Materials include walnut wood and durable steel. While exact space-saved metrics are unavailable, the designs inherently optimize small spaces. Although this collection is premium-priced, it highlights the potential for functional, adaptable furniture to benefit urban dwellers in compact homes.^[3]

[Key words: space-saving, multifunctional furniture, compact living, prototypes, space optimization, dual-purpose functionality, adaptable design, urban living, material reuse, cost-efficiency, furniture innovation, design-driven approach]

1. Materials Cost Analysis:

Bill of Materials (BOM) Analysis: This involves creating a detailed list of all raw materials, components, and sub-assemblies required for a product. The cost of each item is then determined based on supplier quotes, market prices, and quantity discounts. This provides a clear understanding of the direct material costs.^[15]

Value Engineering: This systematic process aims to identify potential cost savings in materials without compromising functionality or quality. It involves analyzing material specifications, exploring alternative materials, and optimizing material usage to reduce waste.^[16]

Life Cycle Cost Analysis (LCCA) of Materials: This method goes beyond the initial purchase price and considers the total cost of a material over its entire lifespan. This includes acquisition, processing, installation, maintenance, replacement, and disposal costs. LCCA helps in choosing materials that might have a higher upfront cost but lower long-term expenses due to durability or reduced maintenance needs.^[17]

Material Price Forecasting: Analyzing market trends, supply chain dynamics, and economic indicators to predict future material price fluctuations. This helps in making informed purchasing decisions and budgeting for potential cost changes.

Bulk Purchasing and Negotiation: Obtaining discounts by purchasing materials in large quantities and negotiating favorable terms with suppliers can significantly reduce material costs.^[18]

2. Production Cost Analysis:

Activity-Based Costing (ABC): This method identifies and assigns costs to specific activities involved in the production process (e.g., cutting, assembly, finishing). By understanding the cost of each activity, manufacturers can identify inefficiencies and areas for cost reduction. **Direct Costing:** This method focuses only on the variable costs directly associated with production (e.g., direct materials, direct labor, variable overhead). Fixed costs are treated as period expenses. This is useful for short-term decision-making but doesn't provide a full picture of production costs. **Absorption Costing (Full Costing):** This method includes all direct and indirect manufacturing costs (fixed and variable) in the cost of goods sold. It provides a more comprehensive view of production costs and is often used for external reporting.^[19]

Job Costing: Used for customized or unique products, this method tracks costs separately for each job or project. This allows for accurate cost calculation for non-standard production. **Process Costing:** Used for mass production of identical units, this method averages costs across all units produced during a specific period.

Lean Manufacturing Principles: Implementing strategies to minimize waste (time, materials, labor) and improve efficiency in the production process can lead to significant cost reductions. **Automation and Technology Investment:** Investing in automated machinery and advanced technologies can increase productivity, reduce labor costs in the long run, and improve the consistency of production.^[20]

3. Long-Term Durability Cost Analysis: Warranty Cost Analysis: Tracking and analyzing warranty claims related to product failures can provide insights into the durability of materials and production processes. High warranty costs may indicate the need for material upgrades or process improvements.

Maintenance Cost Analysis: Estimating the costs associated with maintaining the product over its expected lifespan. This includes regular cleaning, repairs, and potential component replacements. Choosing durable materials and robust designs can significantly reduce these long-term maintenance costs.

Replacement Cost Analysis: Predicting when components or the entire product might need replacement due to wear and tear or obsolescence. This helps in understanding the total cost of ownership over the long term.

Failure Mode and Effects Analysis (FMEA): This proactive method identifies potential failure points in the design and materials and assesses their impact. This allows for design modifications and material selection to enhance durability and reduce the likelihood of costly failures.

Life Cycle Assessment (LCA): While broader than just cost, LCA considers the environmental impact of a product throughout its lifecycle, which is often linked to durability. More durable products may have a lower environmental footprint over time due to less frequent replacement.

Cost-Benefit Analysis (CBA): This method compares the total expected costs (including initial, production, maintenance, and replacement) with the total expected benefits (including functionality, lifespan, and potential resale value) of a product or material choice. It helps in making decisions that maximize long-term value.

Interrelation of Methods: It's important to note that these cost analysis methods are often interconnected. For example, choosing more durable materials (materials cost analysis) might increase initial production costs but could significantly reduce long-term maintenance and replacement costs (durability cost analysis), ultimately leading to a lower total cost of ownership (LCCA and CBA). A comprehensive cost analysis considers all these factors to make informed decisions that balance upfront costs with long-term performance and value.

CONCLUSION : This research examined the increasing importance of multifunctional foldable furniture for space optimization in urban micro-living. The Stephen Kenn and Victorinox collaboration, a key case study, showcased innovative dual-purpose designs like a chair-stepladder and a convertible desk. While lacking specific quantitative data, these prototypes demonstrated the potential for significant space saving with durable materials like walnut and steel. The discussion on cost analysis highlighted the financial considerations of material choices and long-term value. Although the case study represents a premium market, the design principles underscore the broader potential for affordable, space-efficient furniture in urban environments. Ultimately, this research emphasizes the crucial role of intelligent multifunctional design in maximizing space and improving urban living, suggesting future research should focus on quantifiable space savings, cost-benefit analyses, and user feedback for wider accessibility.

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