

Standards for Using the Modular Design Approach in Fashion Design

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Abstract

Fashion designers strive to play a key role in embedding the concept of sustainable fashion with responsibility throughout their production lines, and this has led to the adoption of *modular design*, a key approach to transformable design. Modular design extends the product's life by dividing it into independent components, which enhances interchangeability, adaptability, and removability between these components, resulting in various design patterns that support sustainability. Given the importance of a reference framework to guide designers in utilizing different design methods, this study aims to establish standards for applying the modular design approach in fashion design, based on theoretical and practical insights into modular design. The research followed the descriptive method, and a questionnaire was developed to evaluate the proposed standards. It was presented to a panel of experts in the fields of fashion and textile design. The findings revealed no statistically significant differences among expert opinions regarding the standards, indicating their importance and the validity of their formulation in a way that is applicable and aligned with the requirements of modular fashion design.

Keywords: Sustainable Fashion Design Practices, Transformable Fashion

Introduction and Research Problem

Sustainable fashion aims to create connections between individuals, the environment, society, and the economy by prioritizing quality over quantity. Efficient design and production of clothing are the most critical factors in this movement, as they extend the lifespan of a product—both aesthetically and functionally—thus mitigating environmental, social, and economic harm.

Current practices in design, production, and distribution significantly influence unsustainable consumption behaviors. Consumers today seek not only durable products but also ones that align with their tastes and lifestyles (Sheikh et al., 2021). Therefore, fashion designers must adopt a broader perspective, considering more holistic and responsible design approaches that embrace sustainability in all its dimensions (Sharda & Kumar, 2012).

Fashion designers have explored and developed various sustainable design methods, including *transformable designs* (Fletcher, 2014), referring to garments that can be worn in two or more styles using techniques such as wrapping, tying, or folding (Bilal, 2012). Transformable design offers a practical solution that allows a single garment to be altered into different appearances to meet individual needs—be they aesthetic, functional, or psychological. This approach represents a sustainable alternative to conventional fashion by reducing overall clothing consumption through the modification, reorganization, or replacement of garment parts. It also actively contributes to environmental change by involving consumers directly in the redesign process, thus promoting sustainable practices.

Due to the versatility of such garments, positive outcomes are expected, including increased wear frequency, prolonged garment lifespan (Black, 2008; Gilewska, 2011), delayed psychological obsolescence (Fletcher, 2014), and a reduction in clothing disposal in landfills (Rahman & Gong, 2016).

Modular design—or *unit-based design*—is a form of transformable design. It is often incorporated into the concept of *multi-functional design*, which enhances environmental efficiency in both design and production. This method offers a proven experience in product consumption by dividing the product into independent modules that can be interchanged, adapted, removed, or reassembled. This flexibility allows for continuous growth and change, ultimately extending the product's lifecycle and enhancing its sustainability (Hur & Thomas, 2011; Li et al., 2018).

Modular design has been used in various fields such as interior design, electronics, and the automotive industries, and has recently entered the field of fashion. The concept has gained the attention of many designers due to the diversity of its outcomes (Hamza, 2020).

Design standards are fundamental elements for the success of any design approach, including in the fashion industry. These standards serve as a reference framework that helps designers strike a balance between creativity and functionality, improving production efficiency and the quality of the final product. Since modular design is relatively new to fashion designers, the researcher saw the importance of establishing specific standards for using this approach in fashion design, providing a guiding tool during the design process to help achieve design goals.

Research Problem

1. What is the feasibility of establishing standards for applying the modular design approach in fashion design?
2. What are the opinions of experts in the field of fashion and textile design regarding the design standards proposed for applying the modular design approach in fashion design?

Research Significance

1. The research contributes to encouraging and guiding local designers toward using sustainable design approaches in fashion design.
2. The research helps build design strategies aimed at achieving sustainability in fashion design.

3. The study represents a step toward moving Saudi fashion design beyond traditional frameworks and connecting it with other artistic directions that have not been previously explored in Arab studies.

Research Objectives

This study aims to:

1. Establish standards for using the modular design approach in fashion design, based on both theoretical and practical studies of modular design.
2. Collect expert opinions in the field of fashion and textile design regarding the proposed standards for applying the modular design approach in fashion design.

Research Hypotheses

1. It is possible to establish standards for using the modular design approach in fashion design.
2. There are no statistically significant differences among the average opinions of fashion and textile design experts regarding the proposed standards for applying the modular design approach in fashion design.

Research Methodology

The study adopts the descriptive approach, which is defined as "an attempt to reach accurate and detailed knowledge about the elements of an existing problem or phenomenon, to attain better understanding or to set future policies and procedures" (Al-Mahmoudi, 2019).

Theoretical Framework

The Concept of Modular Design and Its Applications

Modular design refers to a design technique used to develop complex products composed of interchangeable components. These components (modules) must include features that enable them to connect. While each module may perform a separate function, together they can offer a range of functions (Hur & Thomas, 2011). Products designed with easily separable components are referred to as modular designs (Mohsen & Al-Najjar, 2012).

Modular design is widely used in various consumer and electronic products such as automobiles, smartphones, computers, televisions, etc. It also includes software engineering, software product design, and even large websites (with each webpage functioning as an individual module) (UNext Editorial Team, 2022). The term *modularity* originated in computer science in the 1980s in discussions related to interchangeable or removable computer components.

Modular Design Concepts in Fashion

Modular clothing has gained increasing attention as a sustainable design strategy due to its ability to extend garment lifespans through the interchange of modules, potentially transforming business models and consumer purchasing behavior (Zhang et al., 2024).

Studies on modular design frequently use terms such as *Modular Garments*, *Modular Fashion*, *Modularity*, and *Module*, which are often interrelated, as noted by MacDuffie (2013). Understanding these concepts and how to incorporate them into fashion contexts is essential.

Modular Design / Modularity

In fashion, modular design involves dividing a garment into several basic, independent modules (e.g., sleeves, collars), and using potential connection methods (e.g., zippers, buttons), based on the garment's structural design and production process. These modules are then configured according to consumer demands or design objectives to create different garments (Baldwin & Clark, 2003; D. Liu & Gao, 2019; L. Liu, 2017).

Each part of the garment is designed following a unified system that is generalized across multiple basic modules with varying structures and specific functions. These modules can be developed in parallel and manufactured separately, allowing efficient and flexible integration during application. Mansour (2017) and Na (2019) added that each component can be modified independently without affecting others. This system adds value by allowing components to be rearranged or transformed into various combinations to serve practical purposes, making the modules interchangeable and adaptable to different wear conditions.

Garment Module

These are the garment's components and connection mechanisms, forming the basic structure of modular clothing. Zhang et al. (2024) summarized garment module characteristics in three key aspects:

1. **Functionality** – each module has a specific function.
 2. **Independence and Interdependence** – modules are independent yet interconnected within the modular design.
 3. **Compatibility** – module interfaces must be compatible. For instance, if a zipper is used to attach a sleeve to an armhole, both parts must have the exact zipper mechanism.
- **Modular Garment:**
A modular garment is not a single complete piece but rather a collection of detachable garment modules joined using closure systems (Li et al., 2018).
 - **Modular Fashion:**
Modular fashion can be seen as a broad system encompassing design rules, contexts, and applications of modular garments. Its mechanism is defined by modularity throughout the product lifecycle. According to Faure (2023), modular fashion includes garments, shoes, or accessories whose forms can be altered for different uses.

An Overview of the Emergence of Modular Fashion

As an exploratory field within fashion, modular fashion is not a new concept; instead, it is now transitioning from a conceptual space to a commercial one. WGSN, a leading fashion trend forecasting company, described modular design thinking as a "snippet of the trend" in its report titled "*Five Key Trends for 2021 and Beyond: Fashion.*" The report signals new ways to shop, build value into items, and update them with ease, enabling garments or items to transcend seasons and become more functional (Vaid, 2021).

Modular design can be described as "semi-contemporary," with its roots tracing back several decades. It emerged as a response to societal needs and desires for variety, multifunctionality, and adaptability in fashion. Designers began adopting this direction commercially by creating garments suitable for multiple occasions without requiring numerous separate pieces (Faure, 2023).

One of the early examples of modular fashion appeared in 1998 with Jun Takahashi's collection for the renowned streetwear brand *UNDERCOVER*, titled "**Small Parts.**" This collection featured garments made of attachable and detachable pieces, allowing for infinitely customizable looks (Kendall, n.d).



Fig (1): Jacket from Takahashi's "Small Parts" collection, one of the first models applying modular design (Glam Archive, 2024)

Although Takahashi's collection had a strong aesthetic appeal, multi-piece garments were often considered "gimmicky" or "out of place" (Kendall, n.d.). Webb and Maguire (2022) noted a resurgence of this design type during recent fashion weeks in Paris. Sustainability experts argue that shopping behaviors may shift in favor of modular design only if designers move beyond the "gimmick" phase in their designs.

Some startups and high-end designers have embraced this fashion category, and mainstream brands have also begun experimenting with product diversity. The Italian startup ACBC retails *Zip Shoes* that allow wearers to mix and match soles with different uppers made from a variety of leathers. In London, one of the most popular items from the knitwear brand *House of Sunny* is a jacket with removable sleeves. In early 2020, *H&M* launched a multi-functional collection that included an adjustable-length jacket, pants with pockets that transformed into a small clutch bag, and a 3-in-1 garment that could function as a shirt, skirt, or dress. These items were available both online and in physical stores across seven markets in Asia (Vaid, 2021).

Functionality and Aesthetics in Modular Fashion Design

The aesthetics of garments play a crucial role in clothing selection and are just as important as functionality in the context of sustainability. Aesthetic appeal fosters emotional attachment to clothing, thereby extending its life. Well-designed, high-quality garments are more likely to endure over time. For this reason, brands committed to sustainability focus on eco-friendly products, prioritize sustainable raw materials, and aim to deliver valuable outcomes for both customers and the environment (Create Fashion Design, 2022).

In modular fashion design, *functionality* is reflected in the ability of modules to connect through closure systems such as zippers and buttons. These modules must be compatible and properly aligned with the base garment (Zhang et al., 2024). Additionally, they should be flexible, easy to use, and assemble (Koo et al., 2014) and allow for repair or recyclability.

From an *aesthetic* standpoint, modular garments must maintain a neutral design that is easy to interpret, visually balanced, and well-proportioned. Designers employ various techniques to achieve aesthetic appeal, including fabric manipulation, cutting, color, texture, color harmony, badges, accessories, beading, and embroidery, ensuring that the product appeals to a broad audience (Abdulbaset & Al-Shamrani, 2021). Harper (2015) stated that no sustainable design agenda can exist without incorporating both durability (functionality) and aesthetic value. Rothenborg (2016) supported this by emphasizing the importance of combining both in sustainable design.

Sustainability Features in Modular Fashion Design

Modular fashion design supports the circular economy and sustainable practices—provided that it is thoughtfully created with clear usage purposes. According to Na (2019), the value of modular clothing design can be expressed through three key characteristics, which are:

1. **Versatility:**

Modular garments are composed of components and units that can be assembled to create a new look from the same item, offering different functions. For example, a shirt's sleeves can be transformed into short sleeves without needing a separate garment for each variation. This enables diverse styling without overfilling the wardrobe (Faure, 2023; Koo et al., 2014). Such adaptability addresses varying consumer needs in alignment with their preferences and lifestyles, fostering an emotional connection between the wearer and their clothing. This emotional bond, in turn, supports garment longevity and extends the product's life cycle with minimal cost (Koo et al., 2014; Li et al., 2018; Maldini & Balkenende, 2017).

2. **Flexibility:**

The fashion industry typically includes five stages: design, production, distribution, usage, and post-use disposal. Modular fashion allows for high flexibility across all these stages. Sellers can design, produce, and sell modular units based on market demand, and consumers can purchase only the desired components—thereby optimizing resource allocation and reducing energy consumption. According to Vaid (2021), consumers can also stay up to date with fashion trends simply by swapping or updating specific modules (such as collars or cuffs) without needing to replace the entire garment. This approach preserves both the aesthetic and functional aspects of the design (Gwilt, 2020).

3. **Continuity:**

Modular units can be used not only within a single garment but across multiple product lines. A unit purchased from one season's collection can be combined with a unit from a future season. When modular standards are applied across a range of products, they establish a system of long-term usability—making it an effective method for achieving environmental sustainability (Li et al., 2018). This approach offers practical solutions for extending the consumer lifespan of garments (Zhang et al., 2024). Modular fashion products are expected to last longer because their disassembly and reassembly capabilities allow the wearer to replace only the damaged parts, leaving the rest intact—eliminating the need to purchase entirely new garments (Kendall, n.d.; Peter, 2021).

Figures (1 and 2) illustrate the difference between the lifecycle of traditional garments and those designed with modular principles.

4. **Economy** (*Additional criterion proposed by the researcher*):

Modular clothing may require less frequent washing. Users can choose to clean only the specific parts that get dirtier more often than others. Given that washing and drying

accounted for over 13% of household electricity use in the UK in 2014, this process represents one of the most significant contributors to the energy footprint in the lifecycle of cotton and polyester garments. Modular design helps reduce this footprint by allowing individualized care of components instead of laundering the entire garment (Peter, 2021). Additionally, when these modules are worn at appropriate times and in varied ways, the need for constant washing and care is minimized (Kendall, n.d.).

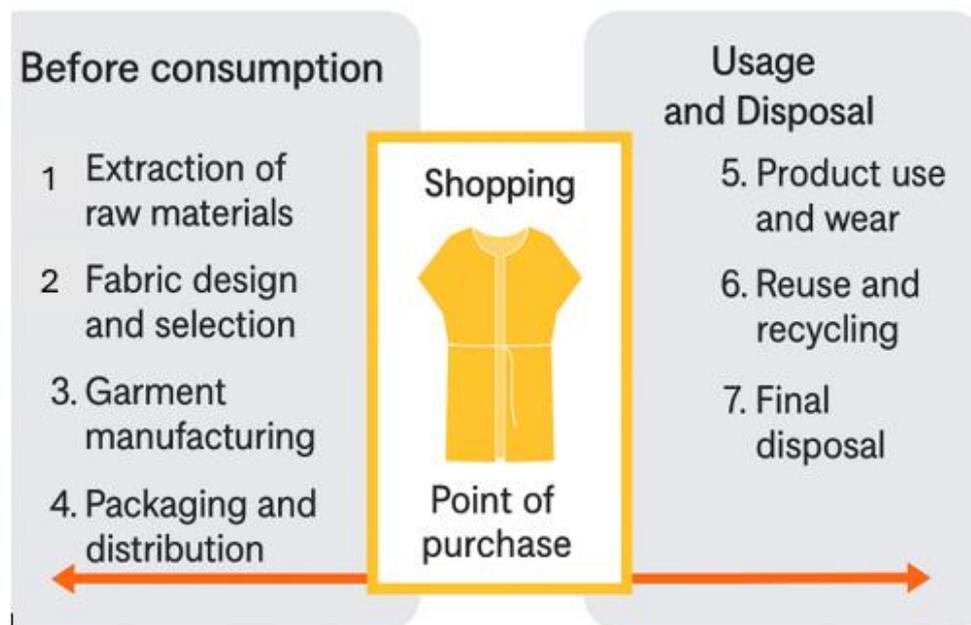


Figure (1): Garment Lifecycle (Niinimaki, 2013)



Fig (2): Modular Garment Lifecycle – Researcher’s adaptation of Niinimaki’s model (2013)

Modular Fashion Design Approaches

Li et al. (2018) classified modular fashion design methods by focusing on how the unit is disassembled and the structural differences in disassembly. They identified **three main categories**, as illustrated in **Figure 3**.

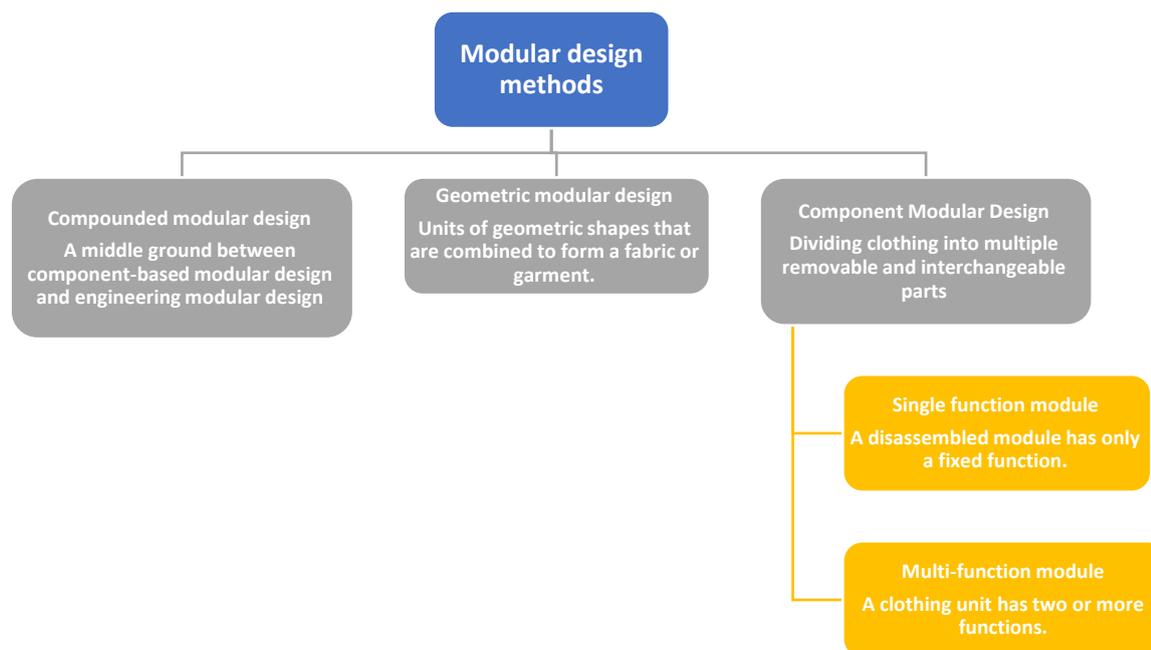


Fig (3): Modular Design Methods (Li et al., 2018)

Experimental

A total of 7 modular fashion designs were executed to explore the challenges of modular design and to establish potential guidelines that fashion designers can follow. The following Table 1 presents these experimental designs:

Table (1)
Research Experimental Designs

Illustration	Design Description
	<p>Design includes: (A) A Sabrina-neck dress with a ruffle detail, mid-calf length; (B1) A long sleeve, open at the center, revealing printed fabric underneath; (B2) A wide raglan long sleeve with elastic cuffs, made of printed fabric; (C) A shawl or scarf that can be attached at the bottom of the dress to provide extra length and a different look.</p> <ul style="list-style-type: none"> ➤ Offers 12 wearing styles ➤ Designed using Single-function + Multi-function modular design
	<p>A back-open dress with a square neckline, fully lined and reversible. It features padded fabric strips (double-sided in different colors) with buttonholes and buttons at the edges. These strips can be attached to the main dress or worn separately as a blouse, shawl, or skirt.</p> <ul style="list-style-type: none"> ➤ Offers 12 wearing styles ➤ Designed using a Compound modular design



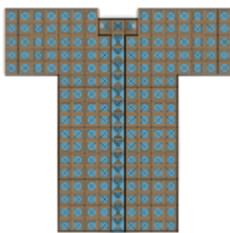
Includes: (A) A long flared dress with shoulder straps; (B) Embroidered belt; (C) Long skirt that attaches to the belt; (D) Short jacket with Sabrina neckline and embroidered long sleeves; (E) Short open-front vest with princess seams; (F) Back flared skirt piece connected to the vest; (G) Separate embroidered unit attached to the vest.

- ▶ Offers **9 wearing styles**
- ▶ Designed using a **Single-function modular design**



A garment that can be a dress or jumpsuit depending on how the pieces are assembled: (A) Upper piece with layered hem and halter neck tie; (B) Corset-style top with princess seams; (C) Long pleated skirt; (D) Long pants with layered side hems; (E) Partial outer skirt with layered, lace-trimmed sides; (F) Laser-cut decorative cape (abaya).

- ▶ Offers **17 wearing styles**
- ▶ Designed using a **Single-function modular design**



Laser-cut square units designed using a **geometric unit method**. The design uses an **interlocking overlapping system** to connect modules, making the final garment voluminous like a 3D structure. The entire garment can be easily disassembled and reassembled or customized based on the wearer's preference.

- ▶ Offers **9 wearing styles**
- ▶ Designed using **Geometric modular design**



A front-open dress with a square neckline, embroidered along the front opening. Includes the following parts: (A) Sleeveless blouse (vest); (B1) Mid-length sleeve; (B2) Extension for long sleeve; (C1) Short skirt; (C2) Skirt extension for a long version; (D) Waistband for separating skirt and blouse.

- ▶ Offers **11 wearing styles**
- ▶ Designed using **Single-function + Multi-function modular design**



A mid-length dress formed by assembling the following pieces: (A) Center panel that runs from neckline to mid-calf, with princess seams and buttonholes on the sides; (B1) Upper side pieces covering bust and armhole area (sleeveless), reversible; (B2) Upper side pieces with short sleeves, also reversible; (C) Lower side pieces from waist to hem in various prints and designs (C1) flared, (C2) ruffled, (C3) pleated, (C4) straight; (D) A strapless reversible dress that can be worn under or over the center panel.

- ▶ Offers **9 wearing styles**
- ▶ Designed using **Single-function + Multi-function modular design**



Formulating and Defining a List of Design Standards to Consider When Using the Modular Fashion Design Approach

The word "standards" is defined in the dictionary as the plural of "standard", which is either a verified or ideal model of how something ought to be, or a benchmark used to evaluate or judge other things (Al-Maany Dictionary, 2001).

Design standards refer to a set of rules or guidelines that must be followed as a reference during the design process or the implementation phase, to achieve the intended function and purpose of the design (Atiya, 2020).

Since the current study aims to formulate a list of design standards for modular fashion design, the researcher followed the procedures outlined in Hassan (2017):

First: Defining the Objective of the Standards List

The list aims to provide standards for using the modular design approach in fashion, serving as a guiding reference for designers adopting this method. These standards are categorized into three main aspects:

- Functional Aspect
- Aesthetic Aspect
- Sustainability Aspect

Second: Sources for Deriving the Standards

- Analytical study of the relevant literature
- Applied (practical) study

Third: Preparing the Standards List

Based on the above sources and the researcher's experimental findings, the resulting standards were formulated as clear statements under each category, totaling 20 standards as follows:

(A) Functional Standards for Modular Fashion Design

The following should be considered:

1. Design adaptability: The design should be intentionally made adjustable from the start, with the parts intended for disassembly clearly identified (e.g., sleeves, dress sections, etc.).
2. Balance in the number of modules: The number of detachable units should not be excessive to avoid overwhelming or confusing the wearer.
3. Balance in the number of layers: Consider the number of layers formed by the attached modules, as too many layers increase garment weight and cause visual bulk and wearer discomfort.
4. Alignment of design lines: The connection lines between units must be precisely aligned to allow seamless assembly.
5. High-quality, durable, and suitable fabrics should be used, ensuring comfort for the wearer.
6. Ease of wear and removal: Fastening systems should be easy to attach and detach.
7. Freedom of movement in all possible styles and configurations of the design.
8. Storage-friendly packaging: Include labeled garment bags with compartments to store individual components, specifying piece count and fastening types.
9. Ease of care: The design should support easy ironing, cleaning, and storage.

(B) Aesthetic Standards

The following should be considered:

1. Unity within the design and among its components.
2. Aesthetic and artistic requirements: Maintain harmony among different design elements such as shapes, lines, textures, and details, and achieve balance in how these elements are distributed across modules.
3. Color coordination: Colors must complement each other across all modular units to create fresh, attractive variations each time the garment is worn.
4. Decoration placement and harmony: Embellishments must be appropriately placed and matched in color and fabric, without being affected by assembly/disassembly.
5. Innovation and originality: Use new techniques, materials, and unconventional designs to add a unique character to the garment.
6. Alignment with contemporary fashion trends, while respecting cultural values and traditions.

(C) Sustainability Standards

1. Maximum versatility with minimal components: Innovative transformational features should allow the garment to serve diverse social needs with fewer parts.
2. Combination of simplicity and elegance: Ensures continued desirability and longer product life cycle.
3. User participation and self-expression: The design should allow consumers to use components creatively, even beyond the intended format, expanding styling options.
4. Reusability and recyclability: Each unit should be reusable even if damaged, or recyclable when desired.
5. Flexible marketing potential: Each modular unit should be marketable and sellable individually.

Fourth: Validation of the Standards List

The standards list was formatted into a questionnaire and submitted to 15 specialists in fashion design to gather feedback on the importance and phrasing of each standard.

Research Results

The research hypothesis stated:

"There are statistically significant differences in the opinions of specialists regarding the design standards proposed for applying modular fashion design."

To verify this hypothesis, Analysis of Variance (ANOVA) was conducted on expert responses to the proposed standards. The findings are presented in **Table 2**:

Table (2)

ANOVA Results – Specialist Opinions on Modular Design Standards in Fashion Design

Source of Variance	Sum of Squares	of Degrees of Freedom	of Mean Square	F Value	Significance
Between Groups	0.026	2	0.013	0.080	0.923
Within Groups	6.332	39	0.162		
Total	6.358	41			

The ANOVA results in Table 2 show that the F value is 0.080, which is not statistically significant since the p-value is 0.923 (> 0.05). This indicates that there are no significant differences in the opinions of specialists regarding the proposed design standards for implementing the modular fashion design approach.

Accordingly, the third hypothesis, which states that there are no statistically significant differences between the opinions of specialists regarding the design standards to be established for applying the modular design approach in fashion design, can be accepted. The researcher attributes this to the clarity of the standards and their formulation in a practical and applicable manner that aligns with the requirements of modular fashion design. The agreement among the evaluators' opinions indicates the importance of these standards and their potential to serve as a key reference for this design approach, as they help provide a framework that can guide designers in creating designs that adhere to specific principles, achieving a balance between creativity and functionality.

This aligns with the study by Kishawy et al. (2018), which emphasized the importance of having clear design standards (such as environmental and productivity criteria) to ensure realistic implementation capabilities in manufacturing processes. Such standards increase the applicability of the approach in practice and support effective and sustainable design decision-making. It also agrees with the study by Reimlinger et al. (2020), which relied on field experiments with design engineers in various countries and showed that the presence of clear and applicable design guidelines improves task completion rates and reduces errors and confusion among different design teams.

Despite the consensus among the evaluators, it cannot be ignored that the importance of specific standards may vary from one designer to another, depending on their areas of specialization or personal design philosophy. For example, some designers may prioritize technical aspects such as innovation and functionality, while others may consider aesthetic or cultural aspects as more important. However, since the study showed no statistically significant differences among the evaluators' opinions, this suggests a general agreement on the priorities or the importance of the standards among the various specialists.

Theoretical and Contextual Contribution

This study contributes to the theoretical body of knowledge by developing a comprehensive and validated set of standards that frame modular fashion design across functional, aesthetic, and sustainability dimensions. While prior literature has emphasized the importance of flexibility, creativity, and eco-conscious practices in design, the present research consolidates these insights into a structured, empirically tested framework that can serve as a reference point for future academic work. Contextually, the research adds value to the practical field of fashion by addressing a gap in standardized guidelines for implementing modular design approaches, which are still relatively underexplored compared to conventional methods. By validating the standards through expert evaluation, the study ensures that they are not only theoretically grounded but also contextually relevant and adaptable to diverse design practices. This dual contribution enhances the applicability of modular fashion in both academic discourse and real-world industry contexts, thereby strengthening the link between research, practice, and the evolving needs of sustainable fashion.

Recommendations

1. Give more attention to conducting additional research on modular fashion design and linking it to various sustainable design practices to reduce environmental impact.
2. Introduce new standards that contribute to the development of the modular design approach, such as those related to technology and cultural diversity, which reflect the directions of the modern fashion world.
3. Conduct future studies to analyze the impact of the standards on modular fashion design processes.

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