

Leveraging the modular design approach to enhance variation of SME LORI jewelry



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ABSTRACT

LORI SME (Small and Medium Enterprise), operating as a producer of fashion accessories characterized by local craftsmanship, encounters challenges in accommodating diverse customer preferences due to resource constraints. To unleash its full potential, there exists a pressing need to adopt innovative design methodologies. This research endeavors to investigate the application of a modular design approach as a strategic solution for augmenting the variety of LORI SME accessories, thereby facilitating the creation of a range of jewelry products that can be easily tailored and adapted to meet individual customer requirements. The study utilizes a qualitative research methodology, encompassing literature reviews, interviews with the owner, exploration of visual motifs and materials, and practice-based research. The findings of this research illuminate that the adoption of a modular design approach significantly enhances the diversity of LORI SME's jewelry offerings, particularly in the case of its necklace products. This modular approach provides SMEs with a broader array of customizable necklace options characterized by distinctive local motifs and high craftsmanship value. These findings furnish valuable insights for SMEs within the LORI SME sector aiming to expand their product portfolios. Additionally, they offer guidance to designers and artisans regarding the potential advantages and challenges associated with the incorporation of modular design strategies in the broader context of small business innovation and product development.



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1. Introduction

Fashion accessories, especially jewelry, have always been a part of human history. When humans first used clothes and tools, jewelry became a part of human culture. It was made of raw materials such as animal skin, feathers, plants, bones, and anything else that could be found in nature [1], [2]. The culture of using jewelry or accessories in traditional societies has long been applied to Indonesian society; conspicuous jewelry creates status and non-verbal symbolic interactions for the wearer [3]. In modern culture, jewelry industries have been developing rapidly using digital technology. Some researchers report the creative process of designing jewelry using 3D and digital applications. The results were new design innovations with more effective design processes, and more diverse designs were shaped [4]. This modern technology provides an opportunity for the craft sector to continue to create unique and distinctive works. Today, craft practitioners see a positive and mutually beneficial relationship between craft and technology. The existence of laser cutting technology, rapid prototyping, CAD, CAM, and others is, in fact, not only seen in an industrial area but also in a

craftsman's studio. This technology has been adapted to the process of making craft works to develop and produce works [5].

Meanwhile, the global accessories fashion industry has experienced a resurgence since the onset of the pandemic [6]. In order to expand their operations more comprehensively, small and medium-sized enterprises (SMEs) in the jewelry sector should harness the influence of marketing, finance, accounting, human resource management, and product strategies on business performance [7]. Consequently, it is imperative to diligently maintain effective product strategies. Failing to do so could impede the progress of the jewelry industry in Indonesia, which has emerged as a priority sector in international trade [8]. West Java, particularly the city of Bandung, has significantly contributed to the development of the accessories industry in Indonesia. Some SMEs within this sector require innovative design solutions to sustain their growth. To accomplish this, SMEs must possess a deep understanding of design innovation capabilities, encompassing technology and the management of the design process [9]. Therefore, the implementation of design innovation is essential and is recommended for the creation of new aesthetic forms that support industrial progress. Among the well-established jewelry enterprises, Lori SMEs, situated in Bandung, West Java, Indonesia, stands out. Lori is a brand of jewelry craft SMEs in Bandung known for its distinctive ornament designs inspired by local Indonesian culture. According to interviews conducted with SME owners, Lori SMEs is currently enhancing its design techniques to reinforce its design characteristics, introduce new variations, and boost sales. They achieve this through the manual beading technique, which involves the assembly of multiple bead components into a unified form.

As depicted in Fig. 1, LORI's existing designs utilize beads as their primary material, incorporating elements from traditional ornaments to establish unique characteristics and employ manual felt iron techniques for production. In their 2020 collection, they continued to utilize beads but introduced a design innovation by dividing the jewelry into three distinct parts: top, middle, and bottom, with each section interconnected by an interlocking ring mechanism. Interviews conducted with business owners revealed a pressing need to advance their techniques through the incorporation of technology and to enhance the visual aesthetics of their jewelry designs with greater diversity. The traditional design and manufacturing processes within LORI SMEs often impose constraints on product variation due to the inherent challenges associated with producing and managing a wide array of unique items. These limitations can hinder innovation and prevent SMEs from fully realizing their market potential. Consequently, LORI SMEs recognized the importance of developing distinctive designs to expand their product range and adopt new technological techniques. Upon an initial analysis of LORI's products (refer to Fig. 1), the uniqueness of their designs becomes apparent through the segmentation of jewelry components and their assembly using a locking mechanism. In terms of form, this approach bears resemblance to the concept of modular design employed in three-dimensional products [10].



Fig. 1. LORI's Jewelry Products

Design based on a modular system is recognized for its capacity to generate diversity through the combination and interchange of distinct modules. The successful execution of such interchange and combination hinges upon the presence of standardized interfaces and interactions among the modules. Modular design, as a conceptual framework, entails the decomposition of a product into discrete components or modules, which can then be assembled or customized to yield various configurations. Consequently, modular systems facilitate the creation of diversity through the amalgamation and substitution of different modules [11]. Fig. 2 illustrates three key advantages associated with modular systems: the ability to generate a diverse range of products, the utilization of commonalities, and the reduction of complexity. Product modularity has found widespread adoption in various companies and has been the subject of extensive research by scholars [12], [13]. It forms an integral part of operations management and is believed to exert a significant influence on sales performance [14]. The concept posits that, through the application of modular design principles, LORI can establish a modular system of components that simplifies customization and variation. This approach allows them to offer a diverse array of accessories without substantially increasing production costs or lead times. Consequently, it empowers customers to personalize their purchases, thereby enhancing satisfaction and fostering loyalty, while simultaneously enabling SMEs to distinguish themselves in a competitive market.

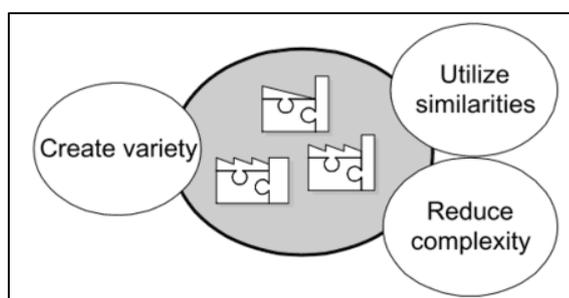


Fig. 2. Modular System Advantages

This research aims to provide insights into the benefits, challenges, and practical implications of adopting a modular design approach within the context of LORI jewelry products. It endeavors to address the following research questions: (1) How can modular design principles be effectively applied to enhance the variety of LORI SME jewelry products?; (2) What are the potential shapes and forms inspired by Indonesian ornaments that can enrich the visual aesthetics of LORI SME jewelry designs?; (3) Which production techniques in jewelry technology are most suitable for realizing modular designs within the context of LORI SME jewelry? To investigate these questions, this research will employ a qualitative approach with a practical design focus. Data will be gathered from SMEs operating in the LORI industry, encompassing an examination of existing jewelry design collections, as well as an exploration of the challenges and requirements inherent to product development. Furthermore, visual and material explorations will be conducted utilizing a modular design approach to create prototype designs.

2. Method

The research methodology employed in this study is qualitative, incorporating data collection techniques such as literature review, interviews, and design exploration. The research process consists of several stages, including scoping, problem analysis, visual analysis, visual exploration, design analysis, prototype production, and experimentation. The literature review encompassed an examination of various journal articles related to modular system techniques in product design and accessories design. This review aimed to provide a comprehensive understanding of the foundational skills essential for the exploration process. Subsequently, interviews were conducted with owners of small and medium-sized enterprises (SMEs) in the LORI industry to identify primary problems and specific needs. These findings formed the central focus of our research investigation. Following this, a visual graphic exploration phase was initiated to generate design variations using digital software. Leveraging graphics within contemporary craft processes was intended to introduce innovative opportunities and approaches, as suggested by prior research [15]. The final step involved prototyping, which was executed using the laser cutting technique. Fig. 3 is the outline of the research methodology that was employed in this study.

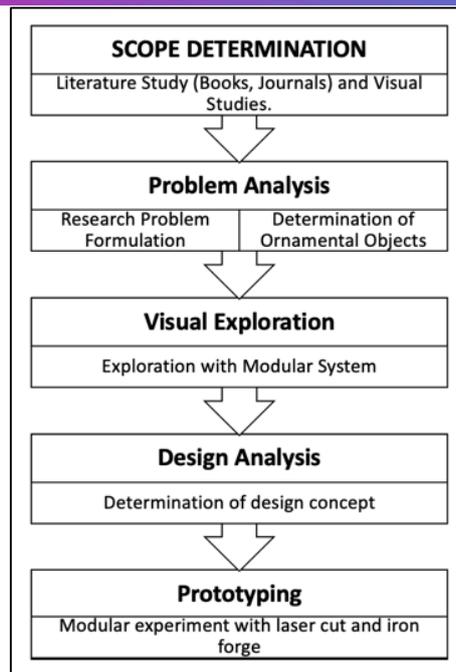


Fig. 3. Research Method

Each stage is explained as follows:

- **Determination of Scope:** In this stage, it is imperative to define the scope of the problem, which serves as the focus of the proposed research and, simultaneously, the object of design development. In this specific case, the subject of design development pertains to the creation of a system rooted in local Indonesian cultural inspiration. Consequently, the identification of local sources of inspiration is essential during this phase.
- **Problem Analysis:** Drawing from prior studies of relevant systems, this stage involves formulating the problems to be addressed. The formulation arises through the application of Escher's tessellation technique infused with Indonesian cultural inspiration, as elucidated in the preceding section. The research problem can be summarized as follows: 'How can motif design innovations be developed using a modular system with local visual inspiration to enhance jewelry accessory product design at LORI SMEs?'
- **Visual Analysis:** Building on insights from previous research conducted by two universities, this stage encompasses the visual analysis of both previously conducted product research outcomes and the local design inspiration to be employed. It is also crucial to undertake a visual examination of the design characteristics specific to LORI SMEs to ensure precise design implementation.
- **Visual Exploration:** Grounded in the outcomes of visual analysis, earlier research, and the determination of local inspiration, a series of visual exploration processes are undertaken to generate innovative design forms derived from the resulting motifs. These innovations are intended for application in fashion accessory products.
- **Design Analysis:** At this juncture, an evaluation of the potential for developing sound product designs and concepts takes place. The objective is to create designs that can be effectively implemented within LORI SMEs.
- **Production of Prototypes and Trials:** During this stage, the previously developed design concepts are put into practice using appropriate techniques and materials. The aim is to produce design prototypes for accessory products at LORI SMEs.

3. Results and Discussions

3.1. Visual Analysis

Visual analysis is conducted using a design semantic approach, specifically by interpreting the signs present in an object. In this instance, the object of scrutiny is the design of ornaments inspired by Batik [16]. The visual analysis process consists of two components: an examination of the visual elements in the inspiration object and an evaluation of the design characteristics unique to LORI SMEs. Based on insights garnered from an interview with Mrs. Elliati, the owner of LORI SMEs, it was determined that the jewelry designs at LORI SMEs exhibit an ethnic character, drawing inspiration from local sources such as batik, weaving, and other cultural artifacts. Consequently, cultural elements like batik motifs possess significant potential for further development. The inclusion of batik motifs is imperative in the design process to reinforce the incorporation of local wisdom, particularly in traditional cloth artifacts such as batik, which is produced by local communities [17]. Furthermore, through visual observations of various jewelry pieces within LORI UMKM, it was discerned that the modularity system is a distinctive technique. In this system, each smallest element functions as a module, subsequently integrating into a larger, cohesive form. This concept is illustrated in Fig. 4.



Fig. 4. Details of Jewelry Design in Lori SMEs

The removable system of the module can be optimized through a modular system design. This modular design minimizes the principal inventory while maximizing diversity. Modular designs are now widely employed across various design fields, including fashion, offering advantages such as ease of assembly/disassembly, adjustability, and cost-effectiveness [18]. Moreover, the implementation of the modular system yields diverse design possibilities, potentially enhancing the effectiveness of jewelry design in LORI SMEs. Flexibility within this design is achieved through a structural arrangement based on symmetry principles and geometric adaptation of forms. Each module follows a tessellated pattern, allowing for various combinations in modular designs [19]. Consequently, module creation and innovation hold significant importance in establishing modularity within design. However, conventional modular techniques typically employ geometric shapes. In this study, we focus on developing organic shapes to introduce novelty. Organic forms draw inspiration from decorative motifs found in batik, showcasing a wide variety of natural shapes, such as floral patterns. Based on these observations, the utilization of organic forms within a modular system can be explored for motif experimentation, ultimately resulting in the production of innovative jewelry modules. The next step involves determining the source of motif inspiration to be utilized in this research. This study draws inspiration from traditional batik motifs to inform design developments tailored to the character of LORI SMEs. Specifically, it focuses on Lasem and Banyuwangi batik motifs, both of which feature a diverse array of organic visuals encompassing flora and fauna, offering substantial potential for inspiring products within the LORI SMEs domain. In the creative process of adapting the modular system for fashion accessory design, the visual analysis process and the strategic partitioning of components are integral at the initial stages, as the modular system operates on the fundamental principle of subdividing shape components into smaller units [20]. Consequently, in

In addition to studying color, the primary shape of the motif becomes a critical aspect to consider when determining the form of motif creation. Furthermore, to enhance the uniqueness of the designs, LORI requires visual inspiration from traditional ornaments. Visual motifs extracted from local Indonesian batik patterns are employed to bolster the design identity of LORI SMEs.

3.2. Analysis of Batik Textile as Inspiration

This study utilized Lasem batik in the form of 'Batik Gendongan Lasem' featuring motifs such as 'Trees of Life' and 'Animals' see Fig. 5. A visual analysis was conducted on the 'Gendongan Lasem' batik fabric adorned with motifs depicting 'Trees of Life' and 'Wildlife.' This analysis aimed to identify motifs with potential development using a modular system [21]. Among the numerous motifs present on the Batik Lasem fabric, the 'Peony' flower ornament found on the 'Hayat Tree' was chosen for modular system processing. This selection was made due to the ornament's visual potential, which offered greater variations compared to other motifs.



Fig. 5. Batik Gendongan Lasem

Table 1 is the result of a visual analysis of Peony flower ornaments performed on the *Gendongan Lasem batik* cloth with the Tree of Life and Animals motif.

Table 1. Visual Analysis of Pohon Hayat Ornament

Ornaments	Visual Analysis
	<p>Composed of tendrils and leaves of various sizes. It has filler details (<i>isen-isen</i>) in each form. The leaves are composed of shapes in red, blue, and <i>sogan</i> (brownish) colors.</p> <p>Composed of shapes such as leaves, tendrils, and petals arranged to resemble flowers. It has filler details on each shape.</p>

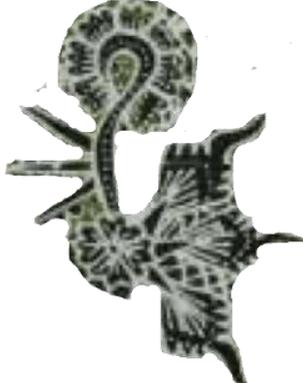
The Banyuwangi batik used as inspiration for this work is batik with the *Gajah Oling* ornament. Fig. 6 is the visual display.



Fig. 6. Batik Banyuwangi

Table 2 is the result of a visual analysis of the *Gajah Oling* ornament.

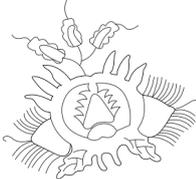
Table 2. Visual Analysis of *Batik Gajah Oling* Ornament

Ornaments	Visual Analysis
	<p>The <i>gajah oling</i> motif has a different central ornament described as a question mark (?) philosophically in the shape of an elephant's trunk, and at the same time described as resembling an ulema (an eel/moa).</p> <p>The <i>Sisik Papak batik</i> motif has a main ornament little squares that flutter the scales neatly arranged with each other. At the top (?) there are <i>isen-isen</i>, namely <i>isen ceceg</i> chopped leaves (points and finger lines).</p> <p>In the middle There are three <i>manggar</i> flower motifs and one flower motif, jasmine. <i>isen-isen</i>, namely <i>isen</i> chopped leaves (dot and finger lines).</p> <p>In the below section There are three dilemma leaf motifs. Glued leaf motif like tendrils, and visually they are leaves that have many branches with leaf character rather spiky. The glued leaf field is built from a combination of zig-zag lines and curved arc lines for the pointed ends of the leaves. Among the leaf motifs, the dilemma is <i>isen-isen</i>, namely <i>isen</i> shredded leaves (finger lines).</p>

3.3. Visual Exploration

Visual exploration in this study aligns with the modular concept, which posits that the creation of modular variety, achieved through combinations and interchangeability, extends beyond the individual module. The notions of variety and interchangeability lack significance in the absence of multiple modules, underscoring the importance of viewing the module as an integral component within a system. Consequently, it becomes evident that modularity is an attribute intrinsically tied to the structure of the system [22]. Thus, the guiding principle of modular exploration in this study involves subdividing the ornament's shape into distinct parts to facilitate the generation of diverse variations. These design principles are supplemented with insights from LORI SMEs owners who possess expertise in the development of accessory product designs. Consequently, the principles governing the visual exploration of fashion accessories, drawing inspiration from batik, encompass the following aspects: (1) Visual exploration is compartmentalized into sections to foster a broad spectrum of shapes. These sections are comprised of three parts: top, middle, and bottom, and correspondingly, the ornament's form is divided into three parts; (2) The modular system is designed to be detachable, necessitating detailed consideration of the interconnections between modules, including the alignment of distances and shapes; (3) User functionality and comfort are paramount, mandating that the design eschews pointed edges on all sides; (4) The dimensions of the accessory design (necklace) do not exceed 15 cm in length and 7 cm in width; (5) Bead elements are incorporated into the design as characteristic features of LORI SMEs accessory designs. Based on these four fundamental principles, the exploration unfolds in two stages: stylized batik form exploration and modular exploration. Table 3 is visual analysis of batik *Gajah Oling* ornament.

Table 3. Visual Analysis of *Batik Gajah Oling* Ornament

Batik Visual	Digital Modification Shape
	
	

From the stylization exploration, the design was continued by dividing the ornament into three parts to function as a modular.

1) *Modular Desain 'Bunga Peony'*

Fig. 7 show depicts the Peony Flower motif, which is subject to processing for modular system exploration. In the modular manufacturing process, the fundamental shape of the peony flower is divided into multiple components to facilitate modularity. The objective is to transform 2-dimensional shapes into applications for 3-dimensional forms by manipulating select portions of the peony flower using a digital platform. The design approach adopts symmetry to appeal to consumers, as methods employing a vertical axis of symmetry are favored over those with a non-vertical axis of symmetry [23].

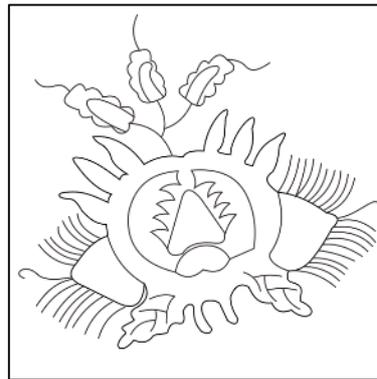
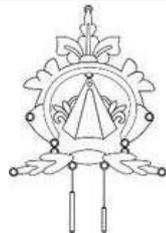
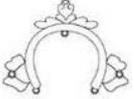
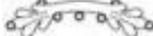


Fig. 7. Stylized Peony Flower Motif

Table 4 presents the results of the exploration process, which has yielded three alternative variations of the peony flower design. Furthermore, it is possible to pair each of these modules with one another. The following section introduces an alternative design inspired by the *Gajah Oling* ornament.

Table 4. Exploration Design of Peony Flower Motif on Modular

Upper Module	Middle Module	Lower Model	Modularization
			
Alternative 1a	Alternatif 2a	Alternatif 3a	Composition Design
			
Alternative 1b	Alternative 2b	Alternative 3b	Composition Design

2) *Modular Desain Gajah Oling*

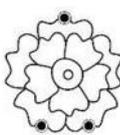
The *Gajah Oling* motif, often found in Indonesian batik and traditional textile designs, depicts an elephant with distinct geometric patterns and decorative elements. This motif typically showcases an elephant with stylized features, often featuring intricate geometric and floral patterns within its body and surrounding it. The *Gajah Oling* motif holds cultural significance and symbolism in Indonesia, representing various themes such as strength, wisdom, and traditional folklore. Fig. 8 is a stylization of the *Gajah Oling* motif.



Fig. 8. Stilasi Motif *Gajah Oling*

The results of the modular exploration reveal a significant degree of variation when the alternative designs are used interchangeably. The success of this design approach hinges on maintaining consistent locking distances in all alternative designs. Consequently, each alternative can be employed interchangeably, thus substantiating the existence of numerous design variations. Among the three alternative designs, their interchange between modules can yield a total of 27 distinct designs. [Table 5](#) is an exploration design for the *Gajah Oling* motif on modular.

Table 5. Exploration Design of *Gajah Oling* Motif on Modular

Upper Module	Middle Module	Lower Model	Modularization
			
Alternative 1a	Alternatif 2a	Alternatif 3a	Composition Design
			
Alternative 1b	Alternatif 2b	Alternative 3b	Composition Design

3.4. Design Analysis

The design analysis is conducted by evaluating designs that have been developed in consultation with LORI UMKM. Several key decisions have been made in the process of design implementation, including the selection of materials, application techniques, and product types. This module is suitable for use in jewelry accessories made from brass metal. The chosen technique for metal experimentation, as determined through direct consultations with LORI SME owners, is laser cutting. The appropriate jewelry-making technique for applying the produced designs is laser cutting with modular repetition to ensure precision. This technique relies on precise interlocks within the modules. Moreover, the intricate details of the design are achieved through forging techniques, which reveal the texture of the metal material, adding aesthetic elements to the jewelry. Based on the visual outputs generated from the modular system, it can be seamlessly replicated, expanding the potential for a wide range of jewelry products, notably necklaces and bracelets. Additionally, it is essential to incorporate connections in the form of links or additional connecting modules to unify the individual modules into a cohesive whole while maintaining their aesthetic appeal.

3.5. Prototype: Application of Selected Motifs on Metal Materials

The application of the design to metal materials is executed by artisans affiliated with LORI SMEs. Fig 9 provides visual representations of the implementation of the Peony Flower and *Gajah Oling* ornament designs using laser cutting on brass metal material. Fig. 9 (a) illustrates the results for Necklace Accessories featuring the Peony Flower design, while Fig. 9 (b) showcases the outcomes of Necklace Accessories adorned with the *Gajah Oling* Design.



Fig. 9. (a) Results for Necklace Accessories with Peony Flower Designs; (b) Results of Necklace Accessories with *Gajah Oling* Design

4. Conclusion

The modular system can also be applied to the design of fashion accessories, drawing inspiration from local batik patterns. The modular approach necessitates careful attention to three key design elements: the top design, the middle design, and the bottom design. One of the advantages of employing the modular technique is the ability to generate numerous design variations from a limited set of modules. When applied to fashion accessory products like necklaces, this flexibility allows for adjustments in dimensions to align with consumer preferences, resulting in a more diverse product range within a single collection. During the implementation process, additional factors, such as inter-module locks, must be considered with great care. This innovative design approach, based on a modular system, contributes to the LORI SMEs' collection with a more personalized touch. Consumers can select designs in accordance with their preferences, free from concerns about uniformity with other customers. This exceptional uniqueness adds a distinctive character to LORI SMEs' designs. Subsequently, considerations for production involve the use of metal molds to replicate similar shapes, ensuring production efficiency. In conclusion, we acknowledge certain limitations in this research. Firstly, the connection between modules in jewelry relies on rings, which have limited strength when frequently detached. Hence, future research should explore alternative systems with stronger detachable connections between interlocking modules. Secondly, the products produced have not undergone market testing in the Lori SME market, necessitating further research to assess the market acceptability of jewelry featuring modular designs. We hope that such endeavors will lead to increased production and enhanced economic value, thereby fostering the growth of the accessory industry in West Java, especially Bandung, in a sustainable manner.

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Declarations

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Conflict of interest. The authors declare no conflict of interest.

Additional information. No additional information is available for this paper.

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