The Modular Design for the Creation of Ceramic Products to Revitalize the Local Industry

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Abstract: This research explores the integration of modular design principles to revitalize the ceramic industry in Saudi Arabia, emphasizing cultural, economic, and philosophical dimensions. Utilizing an interdisciplinary approach that intertwines design theory, cultural philosophy, and industry development, the study conducts a comprehensive analysis. Through extensive literature reviews and participant surveys, it measures user satisfaction and examines the influence of standard design, cultural significance, and philosophical considerations in the ceramic industry. Employing both descriptive and analytical research methods, this study assesses proposed designs through two questionnaires involving 35 participants and 20 specialists. Findings reveal consumer preferences for consistent colors and innovative designs, emphasizing regional relevance to Saudi Arabia. The research not only underscores the potential advantages of modular design but also provides valuable insights for designers, emphasizing the pivotal role of local ceramic industries in promoting cultural continuity and enhancing marketing strategies.
Keywords: Ceramic Products, Cultural Philosophy, Innovation, Modular Design, Product Design, Regional Development.

1. INTRODUCTION

The Kingdom of Saudi Arabia, recognized for its vast natural resources, stands proudly as one of the world's wealthiest nations(Ghamdi, 2020). With an estimated total value of natural resources exceeding $34 trillion and a robust gross domestic product (GDP) of approximately $795 billion (Ministry of Economy & Planning, 2022), the Kingdom boasts a wealth of raw materials conducive to ceramic manufacturing (Vision 2030 Kingdom of Saudi Arabia, 2020). Despite this abundance, the full potential of these resources remains largely untapped (Ministry of Economy & Planning, 2022), presenting a compelling opportunity for both manufacturers and researchers (Levels, 2020). This study endeavors to catalyze the growth of

the ceramic product manufacturing sector within the Kingdom of Saudi Arabia (Hayat & Tahir, 2021). Through a comprehensive exploration of modular design principles and the introduction of innovative product designs, our objective is to elevate the competitiveness of the local ceramic industry. The strategic utilization of locally available resources is anticipated to result in a reduction in production costs, the development of indigenous ceramic products, and the creation of new job opportunities, thereby fostering increased investment within the Kingdom (Ministry of Economy & Planning, 2022). Beyond the economic facets, our research aims to delve into the profound cultural and philosophical implications of modular design in the realm of ceramic product development. By embracing novel design methodologies that not only enhance product performance but also elevate their aesthetic and cultural value, we aspire to stimulate demand for Saudi ceramic products on both domestic and global scales (Arabia, 2022). Our overarching goal is to disseminate Saudi ceramic products, creating new avenues for labor markets within the Kingdom and, in turn, fortifying local industries and enhancing their competitive edge. In summary, this thesis embarks on a journey to uncover the cultural and philosophical dimensions of utilizing modular design in the creation of ceramic products in the Kingdom of Saudi Arabia(Levels, 2020). Through this exploration, our aspiration is not only to fortify local industries but also to empower them to compete vigorously in the global arena (Sun et al., 2022). The seamless integration of modular design principles and cultural exploration promises to unlock new possibilities, positioning Saudi Arabia as a key player in the international ceramic industry.

1.1 Background of the Research

The concept of modular design has gained increasing traction among manufacturers worldwide as a means to swiftly adapt existing products or conceive novel ones tailored to specific customer preferences or market demands(Panarotto et al., 2023). Contemporary manufacturing is witnessing a burgeoning interest in crafting custom designs that precisely cater to the unique needs of diverse clientele (Daneshszand et al., 2023). In the realm of ceramic product manufacturing, modular design methodologies have emerged as powerful tools for devising new products characterized by enhanced efficiency and tailor-made configurations to suit the distinct requirements of various end markets (Zacchei et al., 2022). At its core, modular design hinges on the creation of simpler modular architectures, enabling facile system configuration adjustments to

accommodate evolving demands. Such architectures offer the flexibility to replace individual components as needed, without necessitating an overhaul of the entire system. This is achieved through the separate design and subsequent integration of components, thereby fostering the development of dependable and adaptable systems(Brunoe et al., 2021). Furthermore, the modularity of components simplifies the incorporation of additional features without the need for extensive product redesign. In the ceramics industry, modular components often take the form of discrete functional units that can be flexibly assembled into larger configurations to fulfill specific customer applications. Consider, for instance, a scenario where ceramic parts are assembled in a high-humidity environment(Riascos et al., 2022). In such cases, the advantage lies in the incorporation of components specially designed to meet these unique requirements during the manufacturing process. This modular approach also facilitates swift component replacement, proving invaluable in situations where product segments become damaged during installation or fail to meet expected performance standards. In such cases, it is both cost-effective and time-efficient to replace only the impaired component rather than the entire product (Agkathidis, 2016).

Within the manufacturing industry, normative design signifies a paradigm shift in production processes, aimed at enhancing efficiency without compromising product quality. This transformation involves breaking down the processes or components of finished ceramic products into smaller, independently manufacturable parts (Asión-Suñer & López-Forniés, 2021). These parts are produced autonomously, with assembly being the final step. This methodology not only fosters the emergence of fresh and innovative designs but also holds the potential to revitalize local industries(Albers et al., 2019). By augmenting ceramic product output and optimizing manufacturing processes, normative design improves the work environment and curtails costs associated with designing and developing new products.

In summary, the adoption of modular design principles in the ceramics industry bears cultural and philosophical significance, enabling the rapid adaptation of products to changing market needs while promoting efficiency and innovation in local industries. This research seeks to delve into the deeper cultural and philosophical dimensions of this design approach, exploring how it influences the values and philosophies inherent in ceramic production within the Kingdom of Saudi Arabia.

1.2 Problem Statement

Saudi Arabia aims for industrial advancement, aspiring to achieve self-sufficiency and become a global exporting force. Despite its rich history in ceramic craftsmanship, the traditional methods in the industry prove economically impractical.

The labor-intensive and time-consuming nature of traditional crafting hinders the sector's growth, posing a threat to local employment and cultural heritage preservation. This research addresses the decline in global ceramic production and its impact on Saudi Arabia, focusing on how the infusion of modern design methodologies, specifically modular design, can revive the industry. Beyond economic concerns, the study delves into the cultural and axiological dimensions.

1.3 Research Aim and Objectives

1.3.1 Aim

This study endeavors to delve into the profound cultural and philosophical impact of standard design on ceramic product production, aiming to reinvigorate the local industry, bolster the economy, and foster responsible utilization of natural resources within the Kingdom of Saudi Arabia.

1.3.2 Objectives

Culturally Fortify the Local Ceramics Industry: Examine how the infusion of modular design methodologies can bolster the cultural and artistic identity of the Saudi ceramics industry, enhancing its significance as a repository of heritage and craftsmanship. Economically Empower Through Local Resource Utilization: Explore how the adoption of modular design principles can reduce manufacturing costs by harnessing locally available resources, thus contributing to economic sustainability and self-sufficiency. Philosophical Exploration of Innovative Capacity: Investigate the philosophical underpinnings of how the modular design approach nurtures innovative abilities, fostering the introduction of new ideas and perspectives within the ceramic industry.

1.4 Cultural and Philosophical Impact on Production Facilitation

Analyze the cultural and philosophical aspects of how the modular approach streamlines the ceramic production process, optimizing efficiency and promoting cultural preservation.

1.5 Cultural Heritage and Economic Growth Through Job Creation

Examine how the revival of the ceramic industry creates new employment opportunities, consequently increasing investments in the cultural heritage and economic prosperity of the Kingdom. In summary, this research aspires to explore the intricate interplay between modular design, cultural identity, philosophical values, and economic vitality within the context of ceramic production in Saudi Arabia. By probing these dimensions, it seeks to provide a holistic understanding of how the revitalization of local industries can profoundly impact both culture and economy.

2. LITERATURE REVIEW

2.1 Modular Design Methods and Philosophical Significance

Modular design, when applied to industrial product design, provides two significant advantages(Chen et al., 2022).

Firstly, it enables designers to customize products for individual customers(Asión-Suñer & López-Forniés, 2021)., aligning with a broader philosophical perspective emphasizing customization and adaptability in cultural and artistic expression (Pakkanen et al., 2022).

Secondly, the ease of maintenance and repair, even during active use (Agkathidis, 2016), resonates with the cultural appreciation of craftsmanship (Sun et al., 2022).

2.2 Three Modular Design Methods and their Cultural Implications

-Top-Down Modular Design: This method begins by identifying areas for improvement, breaking them into essential functional modules. Modules undergo refinement, focusing on core functions, symbolizing meticulous craftsmanship (Brunoe et al., 2021).

-Bottom-Up Modular Design: Starting at the micro-level, designing individual components before integrating them, mirrors the cultural value of incremental progress(Chen et al., 2022).

-Hybrid Modular Design: Amalgamating elements from both methodologies(Statham et al., 2022), this pragmatic approach resonates with cultural adaptability and creative problem-solving (Amend et al., 2022), Figure (1) shows the differences between the three modular design methodologies.

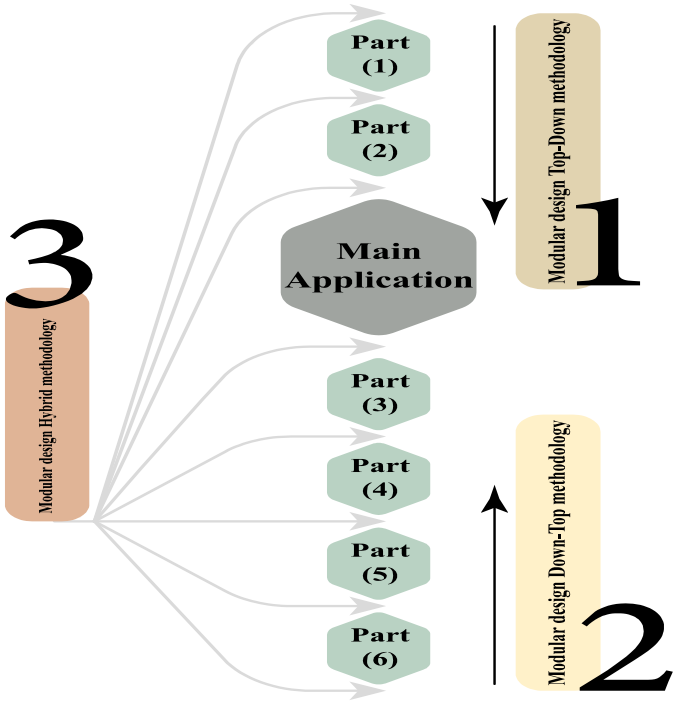


Figure 1: Shows the Differences Between the three Modular Design Methodologies

2.3 Modular Design Methodology in the Ceramic Industry and its Cultural Significance

Traditional porcelain production involves a complex, end-to-end process (Albers et al., 2017). The design phase, from conceptualization to prototype creation (Chen et al., 2022), often spans months to years, contingent on project intricacies and client requirements (Agkathidis, 2016). Modular design enhances quality, reduces costs, fosters innovation, and aligns with cultural appreciation for excellence(Gu et al., 1997).

2.4 The Cultural Significance of Modular Design in Ceramic Production

-Quality Enhancement and Cost Reduction: Modular design enhances the quality of porcelain products(Statham et al., 2022) and streamlines production processes within cultural contexts valuing craftsmanship and attention to detail (Panarotto et al., 2023). -Innovation and Revitalization: Breathes new life into local industries, preserving heritage while embracing modernity, creating appealing(Gershenson et al., 1999), user-friendly, and culturally resonant products(Panarotto et al., 2023). - Customization and Adaptability: Empowers manufacturers to align products with user needs and target markets(Asión-Suñer & López-Forniés, 2021), reflecting cultural adaptability and a philosophical perspective emphasizing individualized experiences and localized solutions(Statham et al., 2022). - Cost Efficiency in Design and Development: Modular design practices significantly reduce

the cost of designing and developing new ceramic products within cultures valuing resourcefulness and sustainability (Wang et al., 2014).

2.5 Advantages of Modular Design in the Ceramic Industry

The advantages of modular design extend beyond mere production efficiency.

-Space Optimization: Reduction of unused space within ceramic products aligns with efficient resource utilization, resonating with cultural values of frugality and sustainability(Sun et al., 2022).

-Design Flexibility: Modular design accommodates diverse applications, reflecting adaptability, a cultural virtue celebrated across various contexts(Gershenson et al., 1999).

-Accessibility for Maintenance: Ease of access to porcelain product parts for maintenance and repair mirrors a commitment to preserving valuable creations.

-Enhanced Troubleshooting: Improved product troubleshooting capabilities and reduced downtime underscore the cultural value of continuous improvement and resilience.

-Cost Reduction: Modular design minimizes overall manufacturing costs, resonating with the pragmatic cultural ethos of resource optimization.

-Reliability and Integration: Enhanced reliability reduces failure rates, and the ability to integrate new designs aligns with cultural values of harmonizing tradition and modernity.

-Manufacturing Efficiency: Streamlined manufacturing and modification processes, coupled with reduced design complexity, embody the cultural ideals of efficiency and effectiveness. In essence, modular design not only enhances production efficiency but also integrates cultural values and philosophies into the very fabric of ceramic product creation, preserving heritage while propelling industries into the future.

3. RESEARCH METHODOLOGY

The research methodology establishes the foundation for a systematic investigation into the application of modular design in ceramic product development, aiming to revitalize the local industry. This chapter outlines the employed strategies and methods to collect essential data, ensuring the study's coherence and scientific rigor.

3.1 Empirical and Experimental Research Approach

The empirical and experimental research approach proves invaluable in exploring modular design types and their applications across various domains. It offers insights into the ceramics industry within the unique context of Saudi Arabia, aligning with the overarching research objectives.

3.2 Descriptive and Analytical Methods

Complementary to empirical research, descriptive and analytical methods play a pivotal role in understanding modular design methodologies in ceramic product development. These methods facilitate the exploration of perspectives from specialists in industrial and ceramic design, ensuring a comprehensive analysis.

3.3 Cultural and Philosophical Exploration

This methodology focuses on exploring the cultural and philosophical dimensions of modular design in Saudi Arabian ceramic production. Engaging with experts aims to discern how modular design aligns with cultural values, heritage preservation, and philosophical ideals of innovation, craftsmanship, and adaptability.

3.4 Research Questions

How does modular design impact the ceramic industry's revitalization in Saudi Arabia? What are the cultural and philosophical dimensions of modular design in ceramic production? How do specialists perceive the application of modular design in the Saudi Arabian context? What are the practical implications and effects of modular design in the ceramics industry?

4. FINDINGS AND ANALYSIS

4.1 Ceramic Product Design Stages with Modular Design Methodology:

In response to challenges faced by the local ceramic industry in Saudi Arabia, modular design emerges as a promising but underexplored approach. The two distinct stages in ceramic product design with modular design methodology involve theoretical characterization and practical application.

4.1.1 Theoretical Characterization Stage

-Problem Definition: Elucidating the main function of the product

through sketches and renderings. - User Needs: Identifying target user characteristics and creating scenarios for user satisfaction(Riascos et al., 2022). - Brainstorming: Fostering innovative ideas through collaborative brainstorming (Pandremenos & Chryssolouris, 2009).

4.1.2 Practical Application Stage

- Modular Design: Deliberating on top-down, bottom-up, or hybrid methodologies aligning with product requirements(Kashaninia & Nikravesh, 2013). - Testing and Reviewing: Constructing 3D models, experimenting with materials, designs(Pandremenos & Chryssolouris, 2009), and shapes, leading to prototype creation(Klocke et al., 2000). - Prototyping: Testing diverse prototypes to identify optimal designs for the target application (Maier et al., 2017). - Finalizing the Design: Preparing technical drawings for 3D printing technology, revolutionizing ceramic design and production(Klocke et al., 2000) Figure 2 shows the stages of designing ceramic products using the standard methodology..

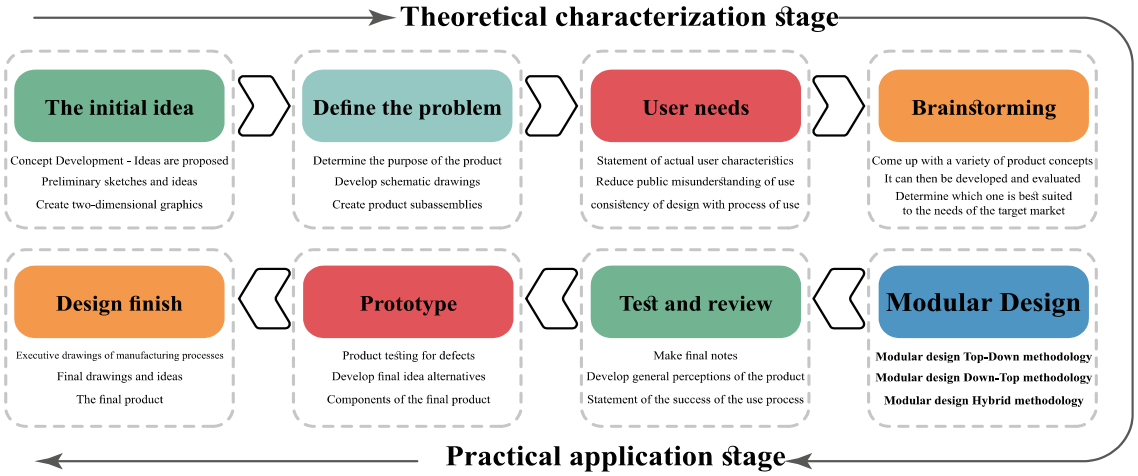


Figure 2: Ceramic Product Design Stages

4.2 Cultural and Philosophical Implications

The structured approach to ceramic product design with modular design methodology holds profound cultural and philosophical implications(AlGeddawy & ElMaraghy, 2013). By aligning with values of craftsmanship, adaptability(Putri & Buana, 2020), and sustainability, these methodologies contribute to a deeper understanding of Saudi Arabian culture and philosophy(Kashaninia & Nikravesh, 2013). In conclusion, the modular design stages not only enhance technical efficiency (Gabrani et al., 2003) but also uphold and celebrate cultural and philosophical values within the ceramic industry, (Pandremenos & Chryssolouris, 2009)

fulfilling the core objectives of this research(Maier et al., 2017).

4.3 The Proposed Set of Ceramic Designs

In response to the prevailing landscape of traditional ceramic products that have graced both local and international markets for generations, often characterized by simplicity and stagnation in design, this research embarks on a creative journey to introduce a series of ceramic designs that transcend convention. These designs not only challenge the status quo but also carry profound aesthetic and cultural values, leaving an indelible impression on users.

4.4 Aesthetic and Cultural Innovation

The proposed ceramic pieces, thoughtfully crafted and meticulously designed, deviate from the well-trodden path of conventionality. They come in an array of sizes and shapes, transforming utilitarian objects into artistic pieces of ceramic craftsmanship. These designs transcend mere functionality; they encapsulate a fusion of aesthetics and culture. They are not just ceramics; they are expressions of art, bearing both cultural and artistic value.

4.5 Functional Versatility

These ceramic designs offer multifaceted utility, enriching the user experience. They can serve as standalone art pieces, each narrating a unique story through its form and ornamentation. Alternatively, they can harmoniously coexist as a collective ensemble, forming a symphony of ceramic artistry within any space. This functional versatility aligns with the essence of modular design, enabling users to curate their ceramic experiences to suit their preferences.

4.6 User Acceptance and Industry Impact

To gauge the success of these innovative designs, two surveys were conducted: one targeted end-user (35 participants), and the other engaged professionals in the ceramic industry and design (20 experts). The results of these surveys revealed overwhelmingly positive responses, with high acceptance rates among both user groups. Users expressed their appreciation for the cultural and aesthetic dimensions embedded in these ceramic creations. Industry professionals acknowledged their potential to revolutionize the local ceramic industry, breathing new life into a craft that had long yearned for innovation.

Table 1(a): Proposed Designs and Stakeholder Opinions

Ceramic Design	Specialists Evaluation		Users Evaluation	
	Technological simplicity	90%	Product attractiveness	91%
	Aesthetic form	96%	Aesthetic form	88%
	Assembly accuracy	95%	Product acquisition	89%
	Color consistency	96%	Color consistency	89%
	Does the implementation of the design revitalize the local ceramics industry?	85%	Do you prefer ceramic products?	89%
	Is the design new and innovative?	90%	Is the design new and innovative?	89%
	Total	92%	Total	89%
	Technological simplicity	97%	Product attractiveness	89%
	Aesthetic form	99%	Aesthetic form	90%
	Assembly accuracy	97%	Product acquisition	86%
	Color consistency	98%	Color consistency	86%
	Does the implementation of the design revitalize the local ceramics industry?	90%	Do you prefer ceramic products?	94%
	Is the design new and innovative?	95%	Is the design new and innovative?	91%
	Total	96%	Total	89%
	Technological simplicity	78%	Product attractiveness	81%
	Aesthetic form	87%	Aesthetic form	88%
	Assembly accuracy	87%	Product acquisition	84%
	Color consistency	90%	Color consistency	84%
	Does the implementation of the design revitalize the local ceramics industry?	80%	Do you prefer ceramic products?	89%
	Is the design new and innovative?	80%	Is the design new and innovative?	80%
	Total	84%	Total	84%
	Technological simplicity	98%	Product attractiveness	91%
	Aesthetic form	98%	Aesthetic form	90%
	Assembly accuracy	98%	Product acquisition	90%
	Color consistency	99%	Color consistency	88%
	Does the implementation of the design revitalize the local ceramics industry?	85%	Do you prefer ceramic products?	83%
	Is the design new and innovative?	95%	Is the design new and innovative?	80%
	Total	95.5%	Total	87%

Table 1(b): Proposed Designs and Stakeholder Opinions

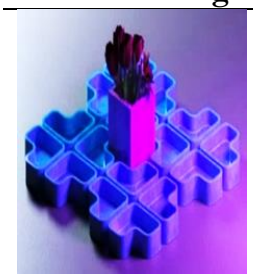
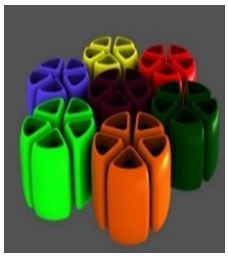
Ceramic Design	Specialists Evaluation		Users Evaluation	
	Technological simplicity	93%	Product attractiveness	90%
	Aesthetic form	92%	Aesthetic form	90%
	Assembly accuracy	95%	Product acquisition	87%
	Color consistency	92%	Color consistency	91%
	Does the implementation of the design revitalize the local ceramics industry?	90%	Do you prefer ceramic products?	94%
	Is the design new and innovative?	80%	Is the design new and innovative?	89%
	Total	90%	Total	90%
	Technological simplicity	77%	Product attractiveness	81%
	Aesthetic form	87%	Aesthetic form	83%
	Assembly accuracy	87%	Product acquisition	81%
	Color consistency	92%	Color consistency	82%
	Does the implementation of the design revitalize the local ceramics industry?	85%	Do you prefer ceramic products?	80%
	Is the design new and innovative?	90%	Is the design new and innovative?	74%
	Total	86%	Total	80%
	Technological simplicity	97%	Product attractiveness	93%
	Aesthetic form	99%	Aesthetic form	90%
	Assembly accuracy	97%	Product acquisition	91%
	Color consistency	98%	Color consistency	93%
	Does the implementation of the design revitalize the local ceramics industry?	95%	Do you prefer ceramic products?	91%
	Is the design new and innovative?	95%	Is the design new and innovative?	82%
	Total	97%	Total	90%
	Technological simplicity	84%	Product attractiveness	88%
	Aesthetic form	90%	Aesthetic form	85%
	Assembly accuracy	89%	Product acquisition	86%
	Color consistency	94%	Color consistency	90%
	Does the implementation of the design revitalize the local ceramics industry?	90%	Do you prefer ceramic products?	98%
	Is the design new and innovative?	90%	Is the design new and innovative?	80%
	Total	90%	Total	88%

Table 1(c): Proposed Designs and Stakeholder Opinions

Ceramic Design	Specialists Evaluation		Users Evaluation	
	Technological simplicity	85%	Product attractiveness	85%
	Aesthetic form	87%	Aesthetic form	84%
	Assembly accuracy	92%	Product acquisition	82%
	Color consistency	86%	Color consistency	79%
	Does the implementation of the design revitalize the local ceramics industry?	95%	Do you prefer ceramic products?	86%
	Is the design new and innovative?	80%	Is the design new and innovative?	74%
	Total	88%	Total	89%
	Technological simplicity	88%	Product attractiveness	84%
	Aesthetic form	91%	Aesthetic form	85%
	Assembly accuracy	90%	Product acquisition	87%
	Color consistency	92%	Color consistency	86%
	Does the implementation of the design revitalize the local ceramics industry?	80%	Do you prefer ceramic products?	83%
	Is the design new and innovative?	80%	Is the design new and innovative?	89%
	Total	87%	Total	86%

Table (1) Interpretations: Table No. (1) presents the evaluations from both users and specialists regarding proposed ceramic designs. The users' evaluation demonstrates a consistent appreciation for product attractiveness, aesthetic form, and color consistency, with an overall average of 86.4%. In contrast, specialists' evaluation tends to rate higher, averaging at 91.3%, showcasing their heightened focus on technological simplicity, assembly accuracy, and the innovative nature of the designs. The specific areas where users and specialists show divergence include product acquisition, preference for ceramic products, and the perception of design innovativeness. Users tend to prioritize personal preferences and the overall appeal of the products, while specialists place greater emphasis on technical aspects and industry revitalization. These interpretations illuminate the multifaceted nature of stakeholder perspectives, emphasizing the need for a balanced approach that caters to both aesthetic and technical considerations in ceramic design. The consistent emphasis on color consistency and aesthetic form across evaluations underscores the significance of these elements in the overall success of ceramic designs.

5. DATA ANALYSIS

Table 2 presents a comprehensive analysis of the survey data collected from both users and specialists. The responses from these two distinct groups shed light on the reception of the proposed ceramic designs and their potential impact on the local ceramic industry.

5.1 User Perspective

The user questionnaire delved into various aspects, including opinions on aesthetic values, color schemes, desire to acquire these products, and the degree of innovation achieved. Remarkably, user responses consistently exceeded the 80% mark, signifying a robust market potential for these innovative ceramic creations. Users not only appreciated the aesthetics but also expressed a strong desire to possess these products, underscoring their appeal to the end consumer.

5.2 Specialist Insights

In contrast, the specialist questionnaire probed the feasibility of manufacturing these ceramic products, the extent to which innovation was realized, the precision of assembly, and the potential of this design approach to reinvigorate the local ceramic industry. Strikingly, specialist responses also consistently surpassed the 80% threshold, indicating favorable conditions for implementation. Specialists attested to the ease with which these designs could be brought to life and affirmed their potential to breathe new life into the local ceramic industry.

5.3 Alignment of Opinions

One intriguing observation is the striking alignment of opinions between users and specialists. The harmony between these two stakeholder groups signifies a strong consensus on the viability and desirability of these innovative ceramic designs. This convergence of perspectives not only validates the research findings but also underscores the profound cultural and philosophical implications of these designs.

5.4 Cultural and Philosophical Implications

The resonance of these innovative ceramic designs among both users and specialists extends beyond mere market potential. It reflects a shared cultural appreciation for artistry and innovation, resonating with the philosophical principles of revitalization and adaptability. These designs

signify more than just products; they symbolize a cultural reawakening and a testament to the enduring relevance of traditional crafts within contemporary contexts. In conclusion, the survey results underscore the cultural and philosophical significance of these innovative ceramic designs, portraying them as catalysts for cultural preservation and revitalization within the local ceramic industry.

Table 2(a): Data Analysis

Aspect	Interpretation
Age	Most users fall within the 20-30 age group, while most arbitrators are in the 41-50 age group. This suggests a specific interest in ceramic products among younger users and an acknowledgment of the industry's significance by older arbitrators.
Educational Level	Survey results show a prevalence of users with bachelor's degrees and arbitrators with doctoral degrees. This suggests a broad appeal of the ceramics industry and its innovative methods across different educational backgrounds, with a particular interest from those holding advanced degrees.
Specialization of Arbitrators	The targeted majors, including industrial design (15%), product design (30%), and ceramic design (55%), reveal a strong representation of the ceramic design field. The survey indicates a notable passion and interest among the surveyed arbitrators for ceramic products.
Product Attractiveness	User satisfaction with product attractiveness is high, ranging from 81% to 93%. This indicates a positive reception of the proposed designs among users, highlighting the appeal of the products in terms of attractiveness.
Aesthetic Form	Both users and arbitrators evaluated the aesthetic form similarly, with results ranging from 99% to 84%. This consistency suggests that the proposed products exhibit a visual harmony that aligns with the preferences of both groups.
Product Acquisition	User responses for product acquisition range between 91% and 81%, indicating a promising retail potential for the proposed designs. The findings suggest that users perceive the products as viable and are likely to acquire them.
Color Consistency	Similar results from users and arbitrators on color consistency, ranging from 99% to 84%, suggest that the proposed colors align well with contemporary color trends. This indicates a careful consideration of color consistency in the designs.
Technological Simplicity	Arbitrators' responses to technological simplicity range from 98% to 77%. While some designs show excellent manufacturing possibilities, there is room for improvement to avoid complexity that could pose obstacles in the manufacturing process.
Assembly Accuracy	Arbitrators rated assembly accuracy between 97% and 87%, indicating a very good level of feasibility for all proposed designs. This highlights a high degree of precision and accuracy in the assembly of the designed products.

Table 2(b): Data Analysis

Aspect	Interpretation
Preference for Ceramic Products	User responses indicate a high preference for ceramic products, with 88% answering "yes," 3% answering "no," and 7.7% responding "maybe." This suggests a strong market potential for ceramic products, supported by positive user preferences.
Revitalization of Local Ceramics Industry	Arbitrators' judgments on the feasibility of implementing proposed designs for revitalizing the local ceramics industry show a positive response, with 87.5% answering "yes." Only 5% answered "no," indicating a strong potential for achieving the research goals.
New and Innovative Design	A significant majority (89% of arbitrators, 82% of users) perceive the designs as new and innovative, with only 7.5% responding "No." The close percentages between arbitrators and users indicate sincerity in opinions and recognition of the innovative nature of the proposed designs.

Table (2) Interpretations: Age: Most users fall within the age group of 20-30 years, where the percentage reached 54.3%, while the majority of arbitrators fall in the age group of 41-50 years, where the percentage reached 50%. This indicates a particular interest in ceramic products among younger users and recognition of the industry's importance by older judges.

Education level: The results of the educational level survey show the prevalence of employees holding a bachelor's degree, 51.4%, and arbitrators holding a doctorate, 55%. This indicates the broad appeal of ceramics and its innovative methods across different educational backgrounds, with particular interest from postgraduate degree holders.

Judges' Specialties: Targeted specializations, including industrial design (15%), product design (30%), and ceramic design (55%), reveal a strong representation of the ceramic design field. The survey indicates a notable passion and interest among the judges surveyed for ceramic products. Product Appeal User satisfaction with product appeal is high, ranging from 81% to 93%. This indicates a positive reception of the proposed designs among users, which highlights the attractiveness of the products in terms of attractiveness. Aesthetics Both users and judges rated aesthetics similarly, with scores ranging from 99% to 84%. This consistency indicates that the proposed products exhibit visual harmony that matches the preferences of both groups. Get Product User responses to Get Product range between 91% and 81%, indicating promising retail potential for the proposed designs. The results indicate that users view the products as viable and are more likely to acquire them. Color Consistency Similar results from users and judges on color consistency, ranging from 99% to

84%, indicate that the suggested colors match well with contemporary color trends. This indicates careful consideration of color harmony in designs. Technological Simplicity Judges' responses on technological simplicity range from 98% to 77%. While some designs demonstrate excellent manufacturing capabilities, there is room for improvement to avoid complexity that can pose obstacles in the manufacturing process. Assembly accuracy the judges rated the assembly accuracy between 97% and 87%, indicating a very good level of feasibility for all proposed designs. This highlights the high degree of precision and precision in assembling the designed products. Preference for ceramic products User responses indicate a strong preference for ceramic products, with 88% answering "yes," 3% answering "no," and 7.7% answering "maybe." This indicates strong market potential for ceramic products, supported by positive user preferences. Revitalizing the local ceramic industry. The arbitrators' rulings regarding the feasibility of implementing the proposed designs to revitalize the local ceramic industry were positive, with 87.5% answering yes. Only 5% answered "no," indicating a strong possibility of achieving the research objectives. New and innovative design A large majority (89% of judges, 82% of users) found the designs to be fresh and innovative, with only 7.5% answering 'no'. The close ratios between the judges and the users indicate the honesty of opinions and recognition of the innovative nature of the proposed designs Figure (3)Evaluation of users and arbitrators of designs.

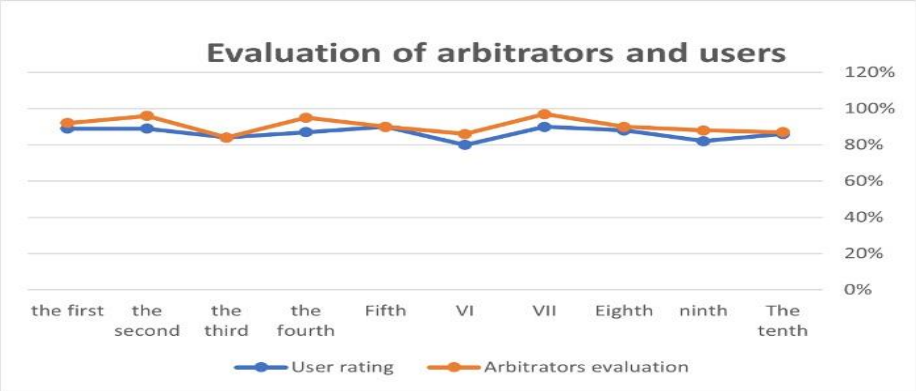


Figure 3: Evaluation of Users and Arbitrators of Designs

6. RESULTS

Unveiling the Philosophical Significance of Modular Ceramic Design: The integration of modularization into ceramic product design yields profound philosophical and axiological insights, reshaping the landscape of the local ceramic industry. The results affirm the transformative power

of this design methodology:

6.1 Autonomy and Adaptability

Modular design endows ceramic products with the autonomy to respond effectively to changes in various components. In the intricate realm of ceramic manufacturing, where one part's design often influences others, modularization minimizes chain interactions. This enhances problem identification, facilitates product maintenance, and expedites repair processes. Companies can then embark on the development of more reliable ceramic product designs and manufacturing systems. Quality is elevated, and costs associated with product changes and redesign are significantly reduced. Moreover, modular products empower after-sales services by simplifying the replacement of defective parts, thereby ensuring customer satisfaction remains paramount.

6.2 Streamlined Manufacturing and Enhanced Diversity

Modularization streamlines manufacturing and production processes, reducing lead times and enhancing specification quality. The reduction in the number of parts and the integration of common ingredients in product variables translate into reduced product costs. This not only bolsters the ceramic industry's economic viability but also aligns with the philosophical principle of resource efficiency. Furthermore, product modularization unleashes greater product diversity, facilitating the innovation process. Manufacturers can adeptly navigate changing environments, swiftly reconfiguring standard components to meet diverse user requirements. This surge in adaptability resonates with the philosophical theme of adaptability and resilience.

6.3 Empowering Local Revitalization

The adoption of the product modular design methodology catalyzes the revitalization of the local ceramic industry. It elevates after-sales services, underpinned by the ease of replacing damaged parts or diversifying product components. This approach, steeped in sustainability and adaptability, positions standard products as the cornerstone of enterprises and manufacturers' strategies. Diversification and continuous product performance enhancement take center stage. The local industry undergoes a renaissance, aligning with the philosophical ideal of preservation and cultural rejuvenation.

7. JUSTIFICATION OF RESEARCH OBJECTIVES

This paper unequivocally attains its research objectives, delving into the philosophical and axiological dimensions of modular design in the realm of ceramic product production and its pivotal role in reinvigorating the local industry.

7.1 Comprehensive Examination of Modular Design

The study meticulously investigates modular design methods and methodologies, unearthing their significance within the broader industrial landscape. This philosophical inquiry illuminates the profound impact of modularization, fostering adaptability and autonomy in ceramic product design.

7.2 Unpacking the Significance for Ceramic Manufacturing

The research journey takes a deeper plunge into the ceramic manufacturing arena, uncovering the critical importance of modular design. By aligning with the philosophical principles of efficiency and resource optimization, the study underscores how modularization streamlines manufacturing processes, reducing lead times and elevating product quality.

7.3 Illuminating the Design Stages

The study meticulously navigates through the stages of ceramic product design, dissecting them into the theoretical characterization and practical application phases. This philosophical exploration accentuates the philosophical principle of adaptability, as modular design empowers designers to respond dynamically to evolving user preferences and market demands.

7.4 Fostering Economic and Cultural Growth

The research findings resonate with the philosophical ideals of cultural preservation and economic growth. By elucidating the benefits of modular design in enhancing the local economy and revitalizing the ceramic industry, this study offers a profound philosophical testament to the enduring value of cultural heritage and industrial progress.

7.5 Promoting Non-Traditional Excellence

The study's revelation that most individuals favor non-traditional

ceramic products carries philosophical weight. It underscores the importance of innovation and originality, aligning with axiological principles that champion the creation of unique and culturally significant artifacts.

7.6 Encouraging Sustainability and Local Industry Support

In advocating for a standard approach to ceramic product design that harnesses local resources, this research aligns with the philosophical ideals of sustainability and community support. It encourages industry stakeholders to leverage natural resources in crafting non-traditional products, thereby bolstering the local ceramic industry and preserving cultural heritage. In sum, this study's achievements reverberate within the philosophical and axiological realms, offering profound insights into the cultural preservation, economic vitality, and innovative spirit that modular design can bring to the ceramic industry. It serves as a philosophical call to action, inspiring designers, and industry leaders to embrace the principles of adaptability, resource efficiency, and cultural rejuvenation.

8. DISCUSSIONS

The current research investigates the application of modular design principles in revitalizing the ceramic industry, focusing on cultural, economic, and philosophical dimensions. A critical review of existing literature in the field reveals a noticeable gap, particularly in studies that explicitly address the intersection of modular design, cultural philosophy, and the ceramics industry, especially within the context of Saudi Arabia. While modular design has been explored in various industries, its cultural and philosophical implications in ceramic production have been relatively underexplored. Adopting an interdisciplinary approach, the research draws on elements of design theory, cultural philosophy, and industrial development. It addresses a void in the literature by examining how modular design can contribute to cultural preservation and innovation in the Saudi Arabian ceramic industry. The study employs empirical research methods, incorporating both quantitative and qualitative data collection techniques. Comparing our findings with existing literature underscores the crucial role of consumer preferences in shaping ceramic design within the Saudi context. While previous research has emphasized the importance of aesthetics, our study specifically identifies a preference for consistent colors and innovative designs among Saudi consumers. This novel insight

contributes to a nuanced understanding of user preferences within the distinctive cultural landscape of Saudi Arabia. Moreover, the delineation of two distinct stages of ceramic product design—the theoretical characterization stage and the practical application stage—provides a comprehensive framework for implementing modular design methodologies. This structured approach not only enhances production efficiency but also aligns with cultural values, emphasizing adaptability, craftsmanship, and sustainability. Integrating cultural and philosophical exploration within the research methodology deepens our understanding of how modular design can contribute to cultural continuity and development. Despite these valuable contributions, the study acknowledges the need for further investigations, particularly regarding the feasibility of large-scale production. This research sets the stage for future studies to explore the scalability and long-term sustainability of implementing modular design principles in the ceramic industry, not only in Saudi Arabia but also in other cultural contexts. In conclusion, this study adds significant insights to the existing body of knowledge by examining the intricate interplay between modular design, cultural philosophy, and the ceramic industry. The findings contribute to understanding how design principles can be tailored to meet the cultural and aesthetic preferences of specific regions, underscoring the importance of a nuanced and culturally informed approach in industrial design.

9. CONCLUSION

In conclusion, this research paper has delved into the intricate realm of modular design methodology within the context of the ceramic industry in Saudi Arabia. The empirical and experimental research approach, coupled with descriptive and analytical methods, has proven invaluable in exploring diverse types of modular design and their applications. The study aimed to revitalize the local ceramic industry by offering insights into the impacts and significance of modular design on ceramic product development. The theoretical characterization and practical application stages of ceramic product design with modular design methodology were thoroughly examined. In the face of challenges encountered by the local ceramic industry, modular design emerged as a promising approach with the potential for profound cultural and philosophical implications. The research findings revealed the two distinct stages of design, highlighting the importance of problem definition, user needs identification, and innovative

brainstorming in the theoretical characterization stage. The practical application stage showcased the deliberation on modular design methodologies, testing and reviewing, prototyping, and finalizing the design. The proposed set of ceramic designs presented a departure from traditional products, introducing aesthetic and cultural innovation. These designs offered functional versatility, enriching user experience, and demonstrating potential industry impact. The positive responses from end-users and industry specialists underscored the viability and desirability of these innovative ceramic creations. The data analysis further supported the success of the proposed designs, with user perspectives aligning remarkably with specialist insights. The convergence of opinions between these two stakeholder groups not only validated the research findings but also emphasized the profound cultural and philosophical implications of these designs. The philosophical exploration of modular ceramic design revealed its transformative power, providing autonomy and adaptability to ceramic products, streamlining manufacturing, enhancing diversity, and empowering local revitalization. The study successfully achieved its research objectives, offering a comprehensive examination of modular design, unpacking its significance for ceramic manufacturing, illuminating the design stages, and fostering economic and cultural growth. The research also promoted non-traditional excellence and encouraged sustainability and local industry support. Acknowledging the limitations of this study, such as the specific focus on the Saudi Arabian context and the need for further exploration in diverse settings, demonstrates transparency and guides future research endeavors. In this regard, future research could delve into cross-cultural applications of modular design in ceramics or explore its implications in different industrial contexts. In essence, this research contributes not only to the technical efficiency of ceramic product design but also to the cultural and philosophical richness within the Saudi Arabian context. As modular design becomes a catalyst for cultural preservation, economic vitality, and creative rejuvenation, it beckons industries and designers to embark on a journey that harmoniously blends tradition and innovation.

10. SUMMARY

In summation, the modular design methodology stands as a beacon of efficiency and economic feasibility in manufacturing, echoing philosophical principles of resource optimization and adaptability. This journey through

the realm of ceramic product design has illuminated the importance of constant innovation and the utilization of natural resources to foster industry, self-sufficiency, and financial prudence. The profound philosophical implications of modular design extend beyond mere efficiency; they underpin a philosophical call to designers and industries to seek novel methods that champion innovation and open new markets for innovative ceramic products. This pursuit, rooted in the wise use of available natural resources, not only bolsters the industrial landscape but also charts a path towards self-reliance and reduced dependence on foreign resources. For ceramic factories, embracing modular design techniques becomes more than a strategic choice; it becomes a philosophical endeavor to promote their products and carve a distinctive identity within a crowded market. In the philosophy of culture and axiology, this commitment to innovation, resource efficiency, and market differentiation encapsulates the spirit of cultural preservation, economic vitality, and creative rejuvenation. In essence, modular design in the ceramic industry transcends its practical applications; it embodies a philosophical testament to the enduring value of adaptability, efficiency, and the harmonious coexistence of tradition and innovation. It beckons industries and designers to embark on a journey that not only enhances their products but also enriches the cultural tapestry of their communities.

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References

Agkathidis, A. (2016). Modular Structures: in design and architecture. *Perovskites* https://www.academia.edu/2380898/Modular_Structures_in_design_and_architecture

Albers, A., Behrendt, M., Klingler, S., Reiß, N., & Bursac, N. (2017). Agile product engineering through continuous validation in PGE–Product Generation Engineering. *Design Science*, *3*, e5.

Albers, A., Bursac, N., Scherer, H., Birk, C., Powelske, J., & Muschik, S. (2019). Model-based systems engineering in modular design. *Design Science*, *5*, e17.

Arabia, I. N. S. (2022). ABOUT. https://www.arabnews.com/node/2303881/business-economy

Asión-Suñer, L., & López-Forniés, I. (2021). Analysis of Modular Design Applicable in Prosumer Scope. Guideline in the Creation of a New Modular Design Model. *Applied Sciences*, *11*(22), 10620.

Brunoe, T. D., Soerensen, D. G., & Nielsen, K. (2021). Modular design method for reconfigurable manufacturing systems. *Procedia CIRP*, *104*, 1275-1279.

Chen, T.-Y., Chang, W.-C., Hsieh, K.-J., & Chang, C.-T. (2022). Advancing Taiwan's traditional craft products: A modular product design model of manufacturing technologies. *Technology in Society*, *71*, 102103.

Daneshszand, M., de Lara, L. N., Makarov, S., Meng, Q., & Nummenmaa, A. (2023). A modular multichannel TMS system with three-axis coil design. *Brain Stimulation: Basic, Translational, and Clinical Research in Neuromodulation*, *16*(1), 134.

Gabrani, M., Dittmann, G., Döring, A., Herkersdorf, A., Sagmeister, P., & van Lunteren, J. (2003). Design methodology for a modular service-driven network processor architecture. *Computer Networks*, *41*(5), 623-640.

Gershenson, J. K., Prasad, G. J., & Allamneni, S. (1999). Modular product design: a life-cycle view. *Journal of Integrated Design and Process Science*, *3*(4), 13-26.

Gu, P., Hashemian, M., Sosale, S., & Rivin, E. (1997). An integrated modular design methodology for life-cycle engineering. *CIRP Annals*, *46*(1), 71-74.

Hayat, A., & Tahir, M. (2021). Natural resources volatility and economic growth: evidence from the resource-rich region. *Journal of Risk and Financial Management*, *14*(2), 84.

Kashaninia, A., & Nikravesh, S. (2013). Modular design using feedback domination method for adaptive regulation of high-order lower-triangular nonlinear systems. *ISA transactions*, *52*(2), 223-230.

Klocke, F., Fallböhmer, M., Kopner, A., & Trommer, G. (2000). Methods and tools supporting modular process design. *Robotics and Computer-Integrated Manufacturing*, *16*(6), 411-423.

Levels, E. (2020). Saudi Standard Classification.

Maier, J. F., Eckert, C. M., & Clarkson, P. J. (2017). Model granularity in engineering design–concepts and framework. *Design Science*, *3*, e1.

Ministry of Economy & Planning. (2022). *Annual Report on the State of the Saudi Economy*.

Pakkanen, J., Juuti, T., Lehtonen, T., & Mämmelä, J. (2022). Why to design modular products? *Procedia CIRP*, *109*, 31-36.

Panarotto, M., Isaksson, O., & Vial, V. (2023). Cost-efficient digital twins for design space exploration: A modular platform approach. *Computers in industry*, *145*, 103813.

Pandremenos, J., & Chryssolouris, G. (2009). Modular product design and customization. Proceedings of the 19th CIRP Design Conference–Competitive Design,

Putri, N. T., & Buana, F. S. (2020). Preventive maintenance scheduling by modularity design applied to limestone crusher machine. *Procedia Manufacturing*, *43*, 682-687.

Riascos, R., Majić, T., Ostrosi, E., Sagot, J.-C., & Stjepandić, J. (2022). Integrated multilayer architecture with multi interface entity model for risk management in modular product design. *Procedia CIRP*, *109*, 647-652.

Statham, W. Z., Jacob, J., & Fridenfalk, M. (2022). Game environment art with modular architecture. *Entertainment Computing*, *41*, 100476.

Sun, X., Liu, X., Yang, X., & Song, B. (2022). Computer-aided three-dimensional ceramic product design. *Computer-Aided Design and Applications*, *19*(S3), 97-107.

Vision 2030 Kingdom of Saudi Arabia. (2020). Government of Saudi Arabia. *Government of Saudi Arabia*, 1-85.

Wang, P., Liu, Y., Ong, S. K., & Nee, A. Y. C. (2014). Modular design of machine tools to facilitate design for disassembly and remanufacturing. *Procedia CIRP*, *15*, 443–448. https://doi.org/10.1016/j.procir.2014.06.085

Zacchei, E., Tadeu, A., Almeida, J., Esteves, M., Santos, M. I., & Silva, S. (2022). Design of new modular metal pallets: Experimental validation and life cycle analysis. *Materials & Design*, *214*, 110425.