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RESEARCH PAPER

Integrating Aesthetics and Ergonomics in Product Design: A Bibliometric Analysis

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ABSTRACT
This study explores how aesthetics and ergonomics intersect in product design through a bibliometric analysis of 317 publications. Scopus was used as the data source, and VOSviewer and RStudio were used to draw a scientific knowledge map. Visual analysis was used to sort out the research lineage. The study found that the number of literature within the search scope is increasing, with countries like China and the United States at the forefront. Results show that China leads in research output but has relatively low international collaboration, while Europe and North America demonstrate stronger cross-country networks. The analysis of the keywords demonstrates that ergonomics-related terms are the dominant term in the literature. Aesthetics emerged as an increasingly important theme, yet it is presented as a less integrated area of inquiry. Thematic mapping indicated four important clusters in the literature: ergonomics and human factors, aesthetics and emotional design, technology/simulation tools, and sustainability and innovation. These findings indicate that ergonomics continues to provide the primary conceptual framework of the discipline, while aesthetics and sustainability represent emerging areas of inquiry. The current study contributes to the fields of design theory and practice with a conceptual framework that integrates ergonomics and aesthetics in design, and by outlining policy implications that could lead to collaboration, interdisciplinarity, and sustainable innovation.

KEYWORDS: *Aesthetic; Ergonomic; Product design; Bibliometric analysis; Sustainability.*

1. Introduction

In recent years, the field of product design has increasingly emphasized the importance of integrating aesthetic considerations (Kumar & Swain, 2023), ergonomic principles, and human factors engineering. This holistic approach ensures that products are not only visually appealing (Braun et al., 2020) but also functional, comfortable, and user-friendly (Jin et al., 2022). Aesthetics, as one of the fundamental elements of product appeal (Schnurr et al., 2017; Shi et al., 2021), plays a critical role in consumer decision-making and product differentiation in a competitive market (Ding et al., 2024; Kumar & Swain, 2023; Wiecek et al., 2019). Aesthetics is not merely about beauty but also involves the perception of beauty (Alechnavicius, 2021), harmony, balance, and emotional engagement. Companies often use aesthetic design as a strategic tool to enhance brand recognition and product appeal (Burnap et al., 2023). For instance, Apple integrates principles such as the golden ratio and visual balance to create designs that convey a sense of order and timelessness. Similarly, Dyson's DC01 vacuum cleaner used a transparent design to showcase its technological complexity, contributing to its commercial success in the UK. Such examples highlight how aesthetics can be studied as the impact of product gestalt on human emotions (Shi et al., 2021). Designers must also consider how consumers perceive utility value through multiple senses, including vision, hearing, and touch (Hekkert & Schifferstein, 2008; ParrasBurgos et al., 2021). Offering a product with both aesthetic features and creative innovation (Pandey, 2022) is one of the goals of contemporary industries to meet both functional

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and affective demands (Bertacchini et al., 2024). Consumers' reactions to products are complex, often involving nuanced positive and negative experiences (Fenko & van Rompay, 2018). This underlines the importance of affective dimensions in user interaction, as suggested by Desmet & Hekkert (2007).

The shape of a product influences the consumer's first impression, so designers must create products that meet consumers' aesthetic preferences (Lu et al., 2021). For this reason, aesthetics has become a critical competitive factor in distinguishing products during decision-making and purchasing behavior (Zhou et al., 2021). A product may appear beautiful to the eye, pleasant to touch, or even smell. Ergonomics focuses on designing products and systems that optimize user comfort, safety, and efficiency (Mosaddad et al., 2022; Naeini et al., 2024). Defined by the International Ergonomics Association (IEA) as the science of understanding interactions between humans and system elements, ergonomics emphasizes the enhancement of human wellbeing and system performance (Salmon et al., 2020). Ergonomic designs use anthropometric data to match products to users' physical and cognitive needs (Naeini et al., 2014). In addition, user satisfaction, a core factor of product usability, depends on the pleasure of use (Hashim et al., 2021). User experience, encompassing all interactions before, during, and after using a product, is significantly influenced by ergonomic design (Hartson & Pyla, 2018). Companies like Herman Miller exemplify the success of ergonomic design; their chairs are not only visually appealing but also provide superior comfort through alignment with the human body's natural form, enabling long-term usage without discomfort. Scientific ergonomic structure, the pleasant feel of touch, and consumer perception are important for customer satisfaction (Chen et al., 2019; Hallencreutz & Parmler, 2021; Stauss et al., 2019; Ummi et al., 2021). Functionality is also an external value of product perception (Iftikhar et al., 2020). It can lead to impulse buying, defined as an unplanned and spontaneous action, triggered by factors during the purchasing process (Yang et al., 2021). The perception of quality is connected to the primary human senses, which carry out the first level of perceived quality characteristics (Braun et al., 2020). Around the 1970s, Donald Norman spoke about products that simultaneously engage human emotion and spirit (P. Liu et al., 2020). More than two-thirds of dissatisfied customers do not voice complaints to service or product providers (Walker, 2017). Instead, some may harm the provider's reputation and income through negative word-of-mouth (Azemi et al., 2020; Kwok, 2021).

1.1. Integration of Aesthetics and Ergonomics in Products

The integration of aesthetics and ergonomics in product design represents a holistic approach to creating products that are both visually appealing and functionally effective. Products that blend aesthetic and ergonomic considerations lead to enhanced user engagement, satisfaction, and overall market success (Jafarnejad Shahri et al., 2024). This synergy helps products meet both emotional and practical user needs, creating a fuller experience. Advances in AI and machine learning now allow designers to improve ergonomics and tailor aesthetics to consumer preferences (Nawi & Yusof, 2024). While all products must fulfill their intended functions, aesthetic considerations are also essential for them to be perceived as high-quality designs (Kumar & Swain, 2023). In categories such as home appliances, aesthetics helps companies achieve product differentiation beyond functional features. For example, the Dyson DC01 used a transparent design to show its complexity and became the UK's bestselling vacuum cleaner. Human factors engineering helps designers create intuitive, efficient, and enjoyable products. However, despite growing interest in aesthetics and ergonomics, few studies explore their intersection, and no bibliometric review exists in this domain (Fig. 1). The idea of combining aesthetics and ergonomics in this research view is more than just the coexistence of features operating independently. This research views the relationship between aesthetics and ergonomics within a synergistic framework whereby visual appeal and functional performance are connected. Integration may involve compromise or trade-offs in certain situations (e.g., when improving ergonomic usability creates changes that compromise aesthetic minimalism). Nonetheless, the current trend in the literature shows that aesthetics and ergonomics often are complementary, for example, products that engage users emotionally, as well as supporting physical comfort and operational efficiencies. The synergistic perspective shows that the best designs achieve balance in the design impacts, where aesthetics informs user perception and preferences, while ergonomic elements provide usable, and

efficient, and long-term satisfaction in use.

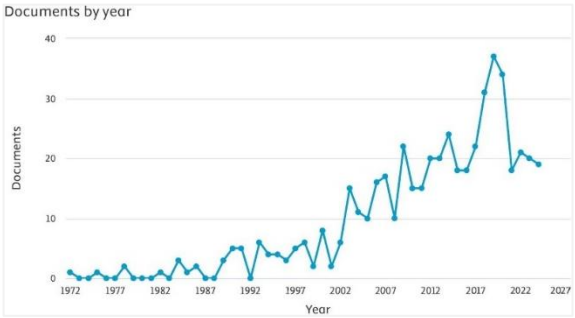

Fig.1. The articles in integrating aesthetics, ergonomics in product design. (Scopus analysis report) Data extraction date, January 2025

Previous research efforts have addressed these factors in isolation, limiting our ability to fully appreciate the holistic impact of integrating aesthetic appeal and ergonomic functionality on the overall user experience.

The research questions are as follows:

Q1: What words and trends are growing?

Q2: Which authors are leading in this field?

Q3: Which countries have done the most research in this field?

To answer these questions, we use the bibliometric method. The bibliometric analysis presented in this study aims to bridge this gap by providing a comprehensive overview of the intersection of aesthetics and ergonomics within the context of product design. Bibliometric analysis is a widely used and robust approach for examining and interpreting extensive scientific datasets. It provides insights into the developmental trends of a particular discipline and highlights emerging areas within it (Donthu et al., 2021). By examining patterns in the publication data, such as citation counts, authorship, and coauthorship networks, bibliometrics can provide valuable insights into the research trends, key contributors, and knowledge structure of a given domain.

This bibliometric review examines trends in studies on aesthetics and ergonomics. By organizing and evaluating relevant literature it offers clearer insights into user needs and experiences, providing a foundation for future research in industrial design and ergonomics. These insights can help designers, manufacturers, and researchers improve product development and customer satisfaction.

2. Materials and Methods

The present study adopted a comprehensive approach to evaluate the research outputs of the field of product design that emphasized the integration of aesthetics and ergonomics using the Scopus database. Scopus database was preferred because it has a wide range of academic publications with high accuracy and fast indexing processes compared to other databases such as Web of Science, Science Direct, and Google Scholar (Zhao et al., 2019). The workflow of the study is presented in Fig.2 which consists of the bibliometrics search using the targeted database (Scopus); scientometric analysis using VOS viewer as the science mapping tool and content analysis of key papers using predefined criteria viz study highlights, the study scope, gaps/ challenges, contribution, and prominence. With the attained keywords, a comprehensive advanced search was done under the title/abstract/keyword field of Scopus and limited it to journal articles, review papers, English language, and engineering. To avoid omitting relevant papers, the date range was set to “all years till 2024”. As of JAN 2025, 503 publications were initially retrieved from Scopus. In this study, we utilize the search string as shown in Table 1 to identify relevant publications in the field of product design. This search string captures a wide range of studies that address the integration of aesthetics, and ergonomics in product design. 317 documents selected for analyzing the resulting dataset, we aim to uncover the key research themes, influential publications, and prominent authors contributing to this multidisciplinary domain.

It is noteworthy that the search string used in this study was the term “product design”. While the term generates a wide-ranging collection of relevant literature, it is possible that some research published using different, albeit related, terminologies (e.g., “industrial design”, “consumer product”, “applied design”, etc.) was not captured by the search. Indeed, it is possible that some relevant studies were in topical, domain-specific disciplines that fall outside of the search string, such as psychology and/or the human design field. The findings highlight the need for future bibliometric studies to use broader sets of key-words or to use different terminology completely, so as to provide a greater breadth of coverage across the relevant disciplines. Such breadth of literature use, in conjunction with the findings of the present study, may generate new insights into how aesthetics and ergonomics relate to each and are integrated in disciplines outside of product design.

Tab.1. Search string. Data extraction date, January 2025

Search String	Documents found	Time period
TITLE-ABS-KEY ("aesthetic*" OR "beauty" OR "visual" OR "stylistic" OR "design-oriented" OR "attractive" OR "sensory" OR "elegant") AND TITLE-ABS-KEY ("ergonomic*" OR "human factor engineering" OR "human factor*") AND TITLE-ABS-KEY ("product design")	503	All years till 2024

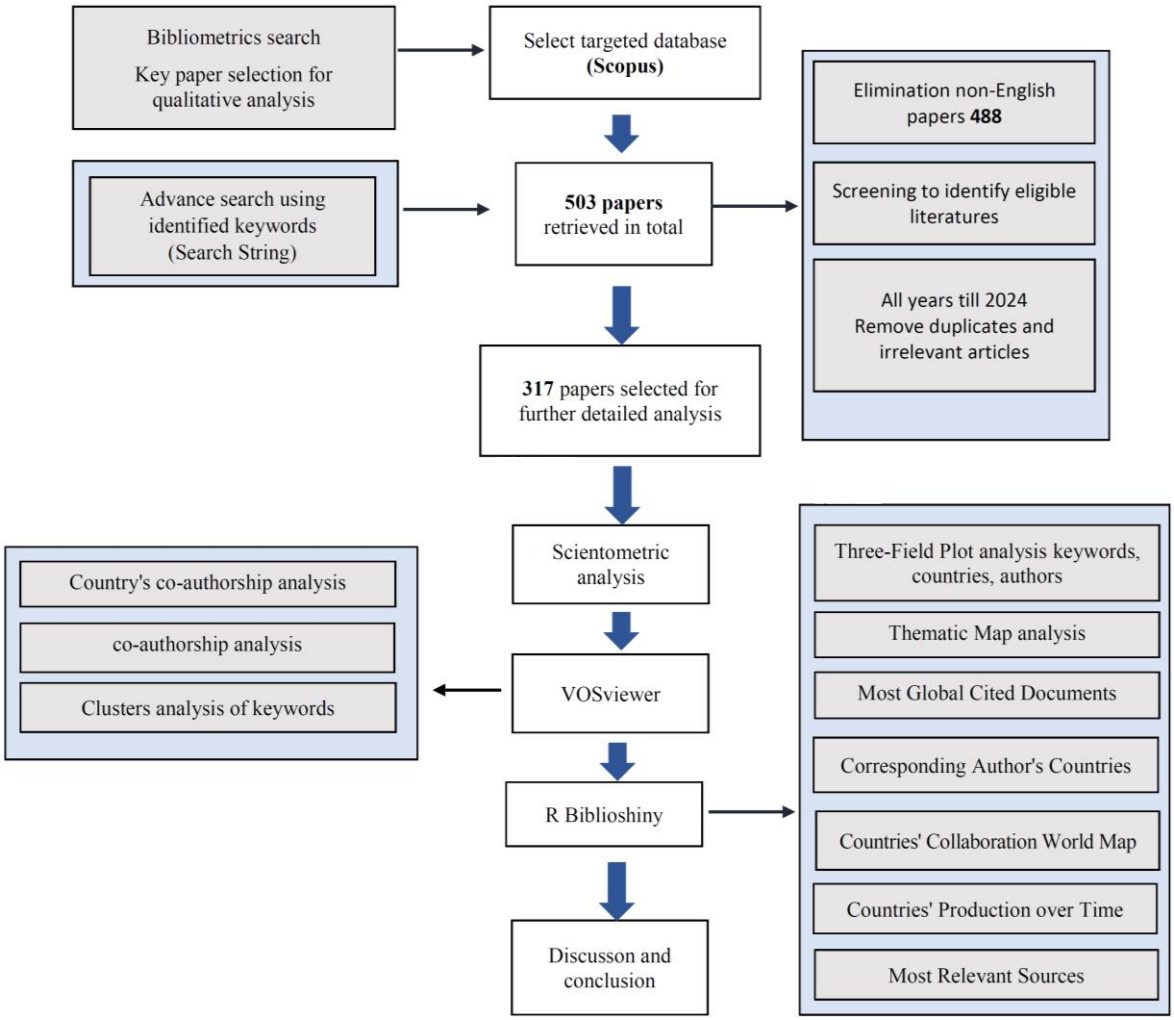

Fig.2. Outline of the study methodology

At the screening and data cleaning stage, all documents that were retrieved underwent thorough review for relevance and accuracy. The progression from 503 initial records to 317 eligible documents was achieved using a systematic screening process. First, duplicates were removed. Second, the inclusion criteria were applied: that is, (i) only journal articles and review papers, (ii) only written in the English language, and (iii) directly addressing questions at the intersection of product design, aesthetics, and/ or ergonomics. Other exclusion criteria were conference abstracts, editorials, book chapters and papers that were exclusively engineering applications without a product design perspective. Titles and abstracts and keywords were screened manually to assess appropriateness. This ensured that the final dataset meeting the aims of the study had methodological rigour and conceptual alignment with the study aims.

3. Results

3.1. VOSviewer

The VOSviewer map generated from this analysis provides a visual representation of the cooccurrence and interrelationships between these critical concepts. VOSviewer is a software tool used for

constructing and visualizing bibliometric networks. It allows researchers to create maps based on citation, cocitation, and coauthorship data, revealing the underlying structure and connections within the research field. In this study, the VOSviewer map highlights the clusters of research topics and the relationships between different concepts in the field of product design.

3.1.1. Country's coauthorship analysis

Figure 3 represents the coauthorship network among countries involved in research on integrating aesthetics and ergonomics in product design, visualized using VOSviewer. The analysis uses a minimum threshold of 5 documents per country and at least 10 citations for inclusion by authors' agreement. The map identifies three primary clusters based on coauthorship strength: Cluster 1 (Green): Includes China, Hong Kong, and Canada, indicating significant collaboration within this region, particularly with China as a central contributor. Cluster 2 (Blue): Features the United States as a dominant node, reflecting its substantial contribution and its collaborative ties with countries like Taiwan, Brazil, and Sweden. Cluster 3 (Red): Consists of European nations such as the Netherlands, France, and the United Kingdom, along with Japan. These countries exhibit strong coauthorship ties, suggesting active transnational collaborations.

The United States as a central node, emerges as the most influential country in this field, acting as a central hub that bridges collaborations between regions. Its strong connections with both Asian (e.g., China and Taiwan) and European countries highlight its leading role in fostering global partnerships. Also, China shows active collaboration with its neighboring regions (e.g., Hong Kong) and with Western countries, reflecting its growing presence in this research domain. Similarly, European countries demonstrate interconnectivity within the continent, with occasional ties to Japan. This coauthorship analysis underscores the global nature of research in aesthetics and ergonomics integration, with distinct regional hubs contributing collaboratively. The presence of multiple clusters suggests both regional specialization and international collaboration, driving advancements in this interdisciplinary field. This network visualization provides valuable insights into the collaborative dynamics and geographic distribution of research efforts, indicating potential areas for enhancing international cooperation.

The descriptive results highlight several notable trends that warrant deeper interpretation. For instance, China's dominance in publication output but relatively limited international collaboration may reflect structural and policy-related factors. China has made substantial national investments in design and ergonomics research, resulting in high productivity; however, linguistic barriers, regional research funding priorities, and a strong emphasis on domestic rather than global networks may explain the lower degree of international co-authorship. In contrast, countries such as the USA and several European nations, while producing fewer total outputs, display stronger international collaboration networks, possibly due to their longer history of academic exchange and participation in multi-country funding schemes.

3.1.2. Co-authorship analysis

Table 2 presents the results of a co-authorship analysis extracted from VOSviewer, illustrating the contributions of authors in the field of integrating aesthetics and ergonomics in product design. The analysis is based on a minimum threshold of two documents per country and a minimum of 50 citations per author. This ensures that only influential authors with a significant contribution to the field are considered. Table 2 lists six authors who meet these criteria, ranked by their total number of citations.

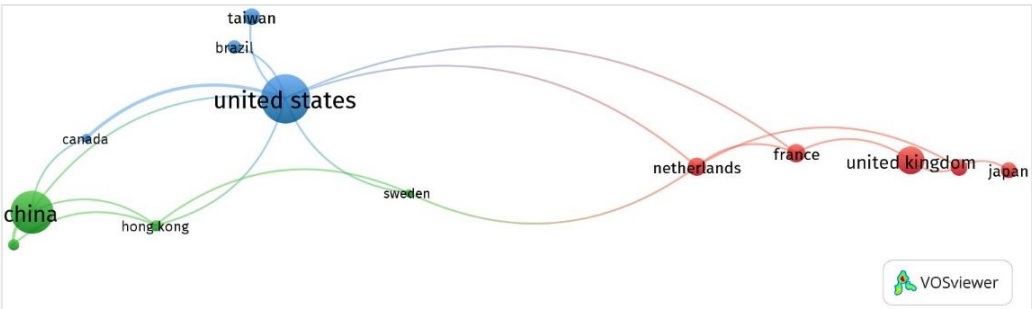

Fig.3. Country's coauthorship analysis. Data extraction date, January 2025 (Minimum number of documents of a country 5_Minimum number of citations of a country 10)

Jan P.L. Schoormans emerges as the most cited author with 750 citations across two documents, highlighting his substantial impact on the discourse in this area. Yili Liu follows with four documents and 224 citations, showcasing a higher publication count but a comparatively lower citation impact per document. Other notable contributors include Deana McDonagh (190 citations) and Sung H. Han (131 citations), both having published two documents each. Martin G. Helander and Monica Bordegoni complete the list with 89 and 68 citations, respectively. This data underscores the diversity of contributions and the varying levels of influence among researchers in advancing the integration of aesthetic and ergonomic principles in product design.

3.1.3. Clusters analysis of keywords

Figure 4 illustrates the co-occurrence network of keywords in the field of integrating aesthetics and ergonomics in product design, generated using VOSviewer. The analysis includes keywords with a minimum of 10 occurrences, out of which 50 meet the threshold. The keyword "ergonomics" appears as the largest and most central node, reflecting its foundational role in the research field. It is interconnected with numerous other keywords, emphasizing its multidisciplinary nature. The map identifies four main clusters, each representing a thematic focus within the field: **Red cluster:** This cluster revolves around design processes and cutting-edge technologies. Key terms include aesthetics, artificial intelligence, human-computer interaction, user experience, conceptual design, and virtual reality. These keywords highlight the integration of advanced tools and techniques to harmonize aesthetics and ergonomics. **Green cluster:** Focused on customer satisfaction and practical applications in industrial and consumer design. Terms like design, sensory perception, kansei engineering, industrial design, and commerce dominate this cluster, underlining the importance of user-centric and market-driven design approaches. **Blue cluster:** Centered around human factors and experimentation. This cluster includes keywords like human, perception, decision making, human experiment, equipment design, and consumer products. It reflects research addressing the cognitive and physical needs of users in design. **Yellow cluster:** Focused on behavioral research that could relate to designing emotionally impactful, sustainable products that connect with user values (Table 3).

The strong links between ergonomics and terms like aesthetics, design, user experience, and kansei engineering underscore the close relationship between these concepts in modern product design. The visualization demonstrates a balanced interplay between technological, user-centric, and experimental themes. The co-occurrence analysis reveals that research in this field is highly interdisciplinary, bridging human factors, advanced technologies, and practical design applications. The three distinct clusters show that while there is a technological focus (e.g., artificial intelligence, virtual reality), significant attention is also given to user satisfaction and experimental methods. This map serves as a roadmap for future studies, identifying key areas of collaboration and growth, such as leveraging emerging technologies to enhance both aesthetics and ergonomics in design practices.

In a similar manner, the larger centrality of ergonomic-related keywords in comparison to aesthetics-related keywords indicates that usability and human factors remain central aspects or entry points of research in product design. Ergonomics is commonly recognized as a requirement for market acceptability, while aesthetics is known to influence the decision-making process of consumers before purchase; however, aesthetics may be dispersed more widely across the disciplines of marketing, psychology, and design theory. Noteworthy here is the disparity indicating that ergonomics is often cited as the “common ground” in product design research, while aesthetics is often implicated in more variable ways across contexts.

Tab.2. Author citation data (Minimum number of documents of an author country 2_Minimum number of citations of an author 50)

Selected	Author	Documents	Citations
1	Schoormans, Jan p.l.	2	750
2	Liu, Yili	4	224
3	McDonagh, Deana	2	190
4	Han, Sung h.	2	131
5	Helander, Martin g.	2	89
6	Bordegoni, Monica	2	68

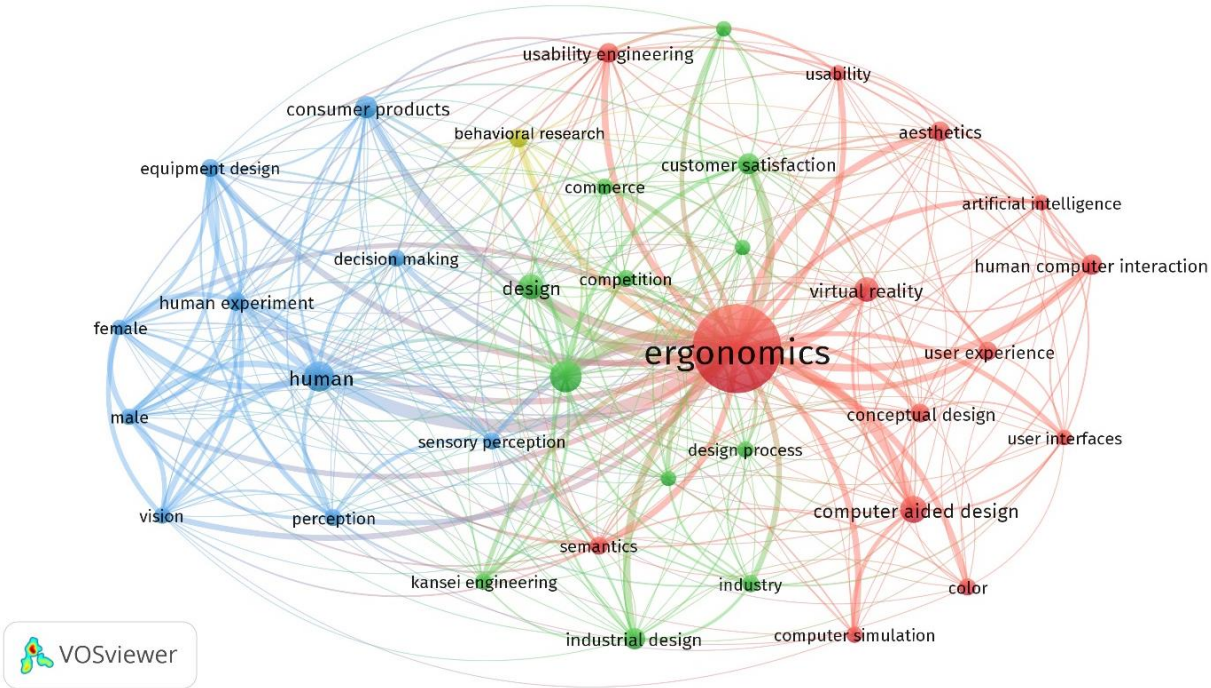

Fig.4. Keywords co-occurrence analysis. Data extraction date, January 2025 (Minimum number of occurrences of a keyword 10 of the 2694 keywords, 50 meet the threshold)

Tab.3. Analysis of the clusters based on their apparent themes and connections

Cluster	Thematic focus	Leading keywords
Red	Ergonomics, Usability, virtual reality	Ergonomics, Usability, Product design
Green	Customer Satisfaction and Design	Competition, Customer Satisfaction, Marketing, Sustainability
Blue	Perception, Decision making	Physiological aspects, Human Interaction
Yellow	Behavioral research, Emotional Design	Behavioral research, Sustainable Development

Collectively, these patterns provide evidence of how institutional priorities, disciplinary orientations, and cultural perspectives influence the bibliometric landscape we are considering.

3.1.4. Interconnections across clusters

Ergonomics is a central term, acts as a bridge between multiple clusters, showing its foundational importance in HCI, design, and human behavior research. Also "Human" as a central theme in the blue cluster, emphasizes the importance of understanding human factors in decision-making and sensory interactions. The connections between clusters reflect the interdisciplinary nature of design, marketing, ergonomics, and psychology. This map reflects a highly interconnected research ecosystem where themes such as ergonomics, user experience, emotional design, and human perception are at the forefront. These clusters provide insight into overlapping disciplines such as HCI, industrial design, marketing, and behavioral research. Together, they represent a comprehensive view of how products, interfaces, and systems are designed to meet human needs and expectations.

3.2. R Biblioshiny

3.2.1. Three-field plot

This Three-Field Plot diagram represents relationships among keywords (DE), countries of authors (AU_CO), and individual authors (AU) in bibliometric data related to the integration of aesthetics and ergonomics in product design (Fig. 5). The leftmost column represents the most frequently used keywords in the bibliometric dataset. Notable keywords include "Design", which is the most general and broad term that is widely connected to various countries and authors, reflecting its centrality in the research domain, and also "Product Design and Industrial Design", which demonstrates a focused interest in applying aesthetics and ergonomics in practical product development. "Ergonomics, Usability, and Human Factors" which emphasizes the importance of user-centric approaches in design

research. Moreover, the terms "Aesthetics and Kansei Engineering" highlight the emotional and sensory aspects of design that are critical for integrating ergonomics.

The central column displays the countries associated with the authors' affiliations. Major observations include that "China" is a major contributor to research in this field, closely associated with multiple keywords such as product design, ergonomics, and user experience. Also, France and Italy: European countries showing significant connections to industrial design, usability, and Kansei engineering. In addition USA and UK: These countries are highly linked to human factors and usability research, underlining their strong emphasis on user-centered design methodologies, and India, Malaysia, Brazil, Spain, and the Netherlands are emerging contributors, reflecting a global interest in the integration of ergonomics and aesthetics.

The rightmost column lists individual authors with notable contributions for instance Zhang Y and Liu Y are likely leaders in research associated with China, contributing across multiple thematic areas. Also Aoussat A and Bouchard C are primarily associated with European research (France), showing strong contributions to industrial design and Kansei engineering. And Bordegoni M represents Italy and is connected to a focus on aesthetics and usability in product design. Also, Bornemann T and Cao Y represent a variety of contributions spanning virtual reality, human factors, and user experience.

The flow of connections from keywords like "design" and "ergonomics" to countries like China, France, and the USA suggests these are central themes in globally distributed research. Authors affiliated with prominent countries demonstrate diverse thematic focuses, indicating the inter-disciplinary nature of the field.

3.2.2. Thematic map

The thematic map from a bibliometric analysis Fig. 6 evaluates the relevance and development of different themes related to integrating aesthetics and ergonomics in product design. The axes on the map represent two key dimensions:

X-axis (Centrality/Relevance degree): importance of the theme in the overall research field.

Y-axis (Density/Development degree): level of internal development of the theme.

This map is divided into four quadrants, each representing a category of themes, which is shown in Table 4. This thematic map indicates that the research field is consolidating around user-centered and industrial design paradigms, with virtual reality and kansei engineering emerging as strategic basic themes likely to become future motor themes. Meanwhile, decision-making methodologies (e.g., AHP) remain specialized niche domains, and classical ergonomics aspects (posture, muscle discomfort) appear to be declining unless revitalized by technological innovation.

The thematic map further provides a roadmap for future empirical research. Motor themes, such as “user experience” and “usability”, could guide experimental studies that measure how specific ergonomic features interact with visual design cues to shape user satisfaction.

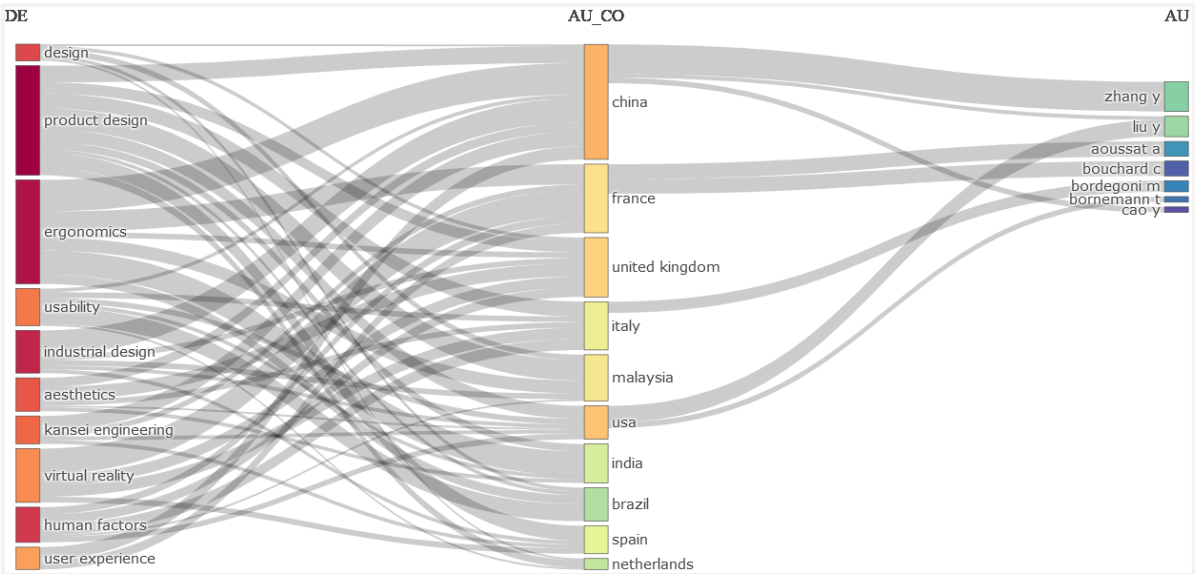

Fig.5. Three-field plot. Data extraction date, January 2025

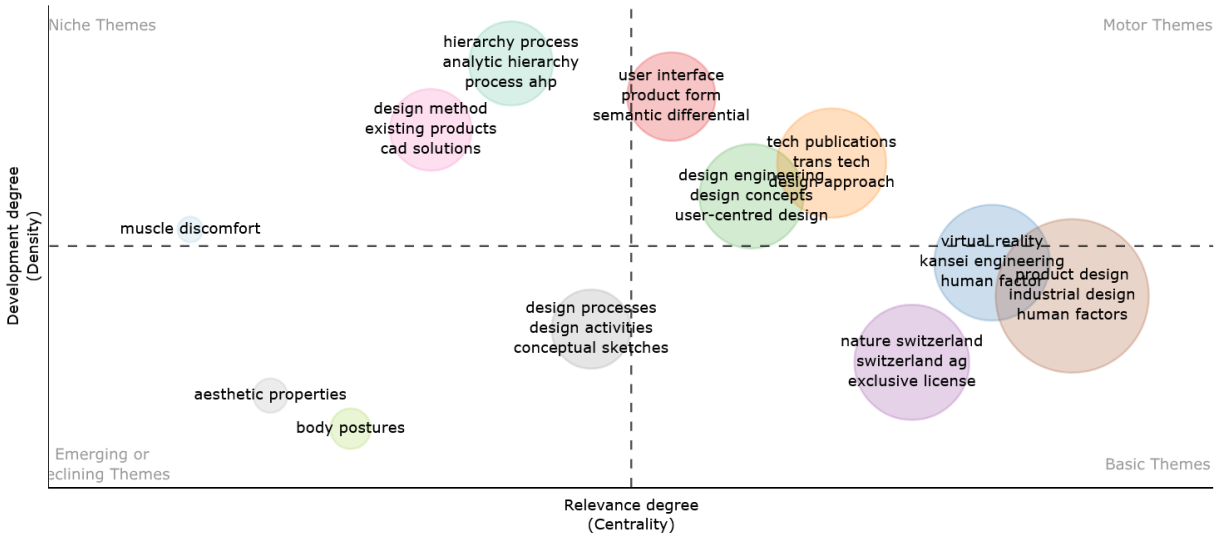

Fig.6. Thematic map. Data extraction date, January 2025

Tab.4. Four themes

N.	Themes (Quadrants)	Key themes identified	Interpretation
1	**Motor themes** (High density, high centrality)	User interface, product form, semantic differential, design engineering, design concepts, user-centred design, tech publications, trans tech approach	Well-developed and highly relevant. These represent the driving forces of the field, consolidating user-centered design and methodological approaches as mature paradigms
2	**Niche themes** (High density, low centrality)	Analytic Hierarchy Process (AHP), hierarchy process, CAD solutions, design methods, existing products	Specialized and internally robust, but peripheral to the mainstream. Important for decision-making and design evaluation, yet not shaping the overall intellectual structure of the discipline
3	**Basic themes** (Low density, high centrality)	Product design, industrial design, human factors, virtual reality, kansei engineering	Highly central but less developed. These form the conceptual backbone of the field and signal promising directions for future development. Virtual reality and kansei engineering, in particular, are poised to evolve into motor themes.
4	**Emerging or declining themes** (Low density, low centrality)	Aesthetic properties, body postures, muscle discomfort	Marginal and weakly developed. May reflect declining research fronts unless revitalized, but could also represent emerging areas if linked to new technologies such as immersive environments and ergonomic evaluation in VR.

Basic themes, including “design process” and “human factors”, call for applied research that tests how interdisciplinary design teams can integrate aesthetics and ergonomics systematically within industrial practice. Niche themes, such as “virtual prototyping” or “3D modeling”, point toward specialized opportunities where emerging technologies may refine both aesthetic evaluation and ergonomic testing. Finally, emerging/declining themes highlight evolving areas like “sustainability” and “emotional design”, which may benefit from empirical studies linking ecological considerations with both user perception and comfort. Taken together, the thematic map underscores how bibliometric trends can inform concrete, testable research agendas.

3.2.3. Corresponding author's countries

Table 5 presents the distribution of articles based on the corresponding author’s country, offering insights into the geographical contribution to research in integrating aesthetics and ergonomics in product design. The analysis includes the

number of articles, the percentage of total articles, and the distinction between Single Country Publications (SCP) and Multiple Country Publications (MCP), along with their respective percentages. China, as a Leading Contributor, dominates the research landscape with 39 articles, accounting for 12.3% of the total articles. Almost all articles (38 out of 39) are SCPs, indicating that most research from China is conducted domestically, with limited international collaboration (MCP%= 2.6%). The USA has 14 articles (4.4%), with a balanced contribution between SCPs (12) and MCPs (2), reflecting a relatively higher degree of international collaboration (MCP%= 14.3%). France, with 9 articles (2.8%), demonstrates the highest MCP% (44.4%), indicating that nearly half of its articles involve international partnerships. Japan also exhibits a strong collaborative approach, with 22.2% of its articles being MCPs. Spain, the UK, India, Brazil, Italy, and Korea have smaller contributions, each accounting for fewer than 10 articles. Among them, Italy shows a notable MCP% (16.7%), while Spain and India have no international collaborations (MCP%= 0).

Table 5 highlights significant disparities in research output and collaboration trends across countries. China is the most prolific contributor but exhibits limited international partnerships. In contrast, countries like France and Japan have a smaller output but demonstrate stronger collaboration, as reflected in their high MCP percentages. These findings suggest opportunities for fostering greater international collaboration, particularly for countries with high SCP contributions like China. Strengthening partnerships could enhance the global impact and diversity of research in integrating aesthetics and ergonomics in product design.

3.2.4. Countries' collaboration world map

The "Countries' Collaboration World Map" illustrates the patterns of international collaboration in research exploring the relationship between aesthetics and ergonomics in product design (Fig. 7).

Tab.5. Corresponding author's countries

Country	Articles	Articles%	SCP	MCP	MCP%
China	39	12.3	38	1	2.6
Usa	14	4.4	12	2	14.3
France	9	2.8	5	4	44.4
Japan	9	2.8	7	2	22.2
Spain	8	2.5	8	0	0
United Kingdom	8	2.5	7	1	12.5
India	7	2.2	7	0	0
Brazil	6	1.9	6	0	0
Italy	6	1.9	5	1	16.7
Korea	6	1.9	6	0	0

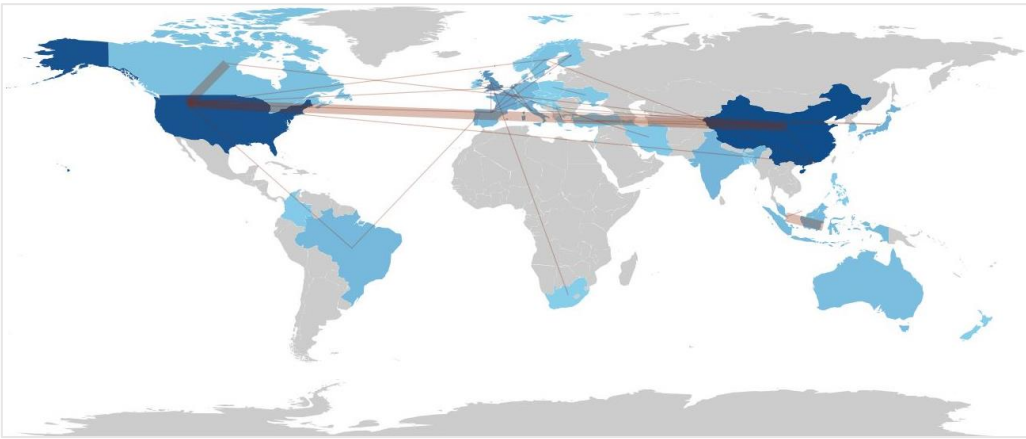

Fig.7. Countries' collaboration world map. The map shows strong international partnerships between the USA and European countries, while China, despite high productivity, demonstrates fewer international links. Emerging collaborations are visible in Southeast Asia, indicating potential future growth in cross-regional research. Data extraction date, January 2025

The geographic distribution displayed in Fig. 7 makes visible that strong links of international collaboration are located in North America and Europe, and the USA sits in the middle of the hub of global research relationship links, having links to country collaboration from different parts of the globe. While China produces a high level of research productivity in research on aesthetics and ergonomics, it has limited collaboration links compared to other countries, indicating challenges of work productivity matched with international collaboration. Emerging network links from China to Southeast Asia may present an opportunity for growth in cross-regional collaboration. This suggests that China will continue to be a central player in international partnerships in the field of aesthetics and ergonomics. Strong links to other countries (particularly in Asia, Europe, and North America) indicate that China is becoming a representative and contributor to this field. Table 6 shows more details.

3.2.5. Countries' production over time

Fig. 8 depicts the evolution of article production over time in the context of research on "Integrating Aesthetics and Ergonomics in Product Design". The graph highlights contributions from five countries: the USA, China, France, the United Kingdom, and Malaysia, spanning from 1984 to 2023. The USA and China dominate the field, representing key hubs for research in this area. Their institutions and collaborations are likely driving innovation and publication trends. The steady contributions from France and the UK indicate their established research frameworks in design-related studies. The late but growing involvement of Malaysia suggests a developing interest in design research, possibly driven by regional demands and growing academic capacities. This data highlights a competitive and dynamic global research environment, with significant contributions from both historically dominant and emerging nations in the field of product design. Future bibliometric analyses could further explore the drivers behind these trends and the impact of collaborations on research outputs. The increasing trends for most countries after 2000 reflect the rising global interest in integrating aesthetics and ergonomics in product design. The collaboration and advancements in technology during this period likely played a role.

Tab.6. Countries' collaboration in research on aesthetics and ergonomics

Region/Country	Collaboration Highlights	Implications
USA	− Most prominent collaborator globally. − Numerous links with countries worldwide, especially Europe.	− Central role in fostering international partnerships. − Likely provides resources, funding, or leadership in joint projects.
China	− Key player with strong connections globally, particularly Asia, Europe, and North America. − Strong China-Europe and China-USA connections.	− Acts as a bridge between Asian and Western research communities. − Investments in research capacity, linked to large-scale manufacturing applications.
Europe (UK, France, Germany, Italy)	− Dense interconnections within the region. − Frequent collaborations with both the USA and China.	− Indicates robust regional networks. − eflects shared research goals and knowledge transfer in design innovation.
India, Brazil, Malaysia	− Increasing participation in global collaborations. − Links with established research leaders like USA and China.	− Potential to build local expertise. − Opportunity to address region-specific design challenges.
USA-Europe	− Strong bilateral links.	− Shared research goals, funding exchanges, and knowledge transfer.
China-Europe	− Growing collaboration.	− Highlights China's integration into global research networks.
China-USA	− Significant partnership.	− Reflects China's expanding role in international research.
Regional partnerships (Europe, Asia)	− Concentrated collaborations within regions.	− Reflect shared regional interests or localized initiatives.

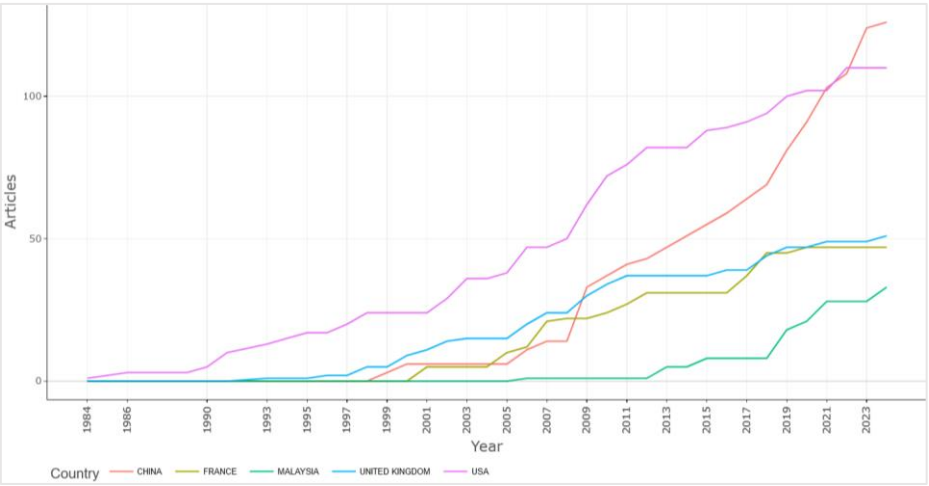

Fig.8. Countries' production over time. Data extraction date, January 2025

3.2.6. Most relevant sources

Figure 9 shows the key sources of publications, as well as the documents that are cited worldwide in the domain. Design Studies and Applied Ergonomics both function as interdisciplinary circles, fusing together design theory, ergonomics, and human–computer interaction. The cited documents and books signify a mix of ergonomic theories from yesteryears, with newer items appearing to connect aesthetics within the user experience. The distribution of the documents signifies that yes, ergonomics is the backbone of the domain, but aesthetics while still emerging in terms of directionless research, are gaining traction in high-profile journals.

The dominance of certain sources like "Advances in Intelligent Systems and Computing" and "Ergonomics" suggests that these outlets should be prioritized for future literature reviews or for submitting related manuscripts. The diversity of publication venues highlights the multidisciplinary appeal of this research area, indicating opportunities for collaboration between engineers, designers, and ergonomics experts. These findings could also guide researchers in targeting the most impactful sources to disseminate their work effectively and reach relevant audiences. This chart highlights the importance of selecting suitable publication venues based on the study's scope and intended audience. It also highlights the evolving and interdisciplinary nature of research in integrating aesthetics and ergonomics in product design.

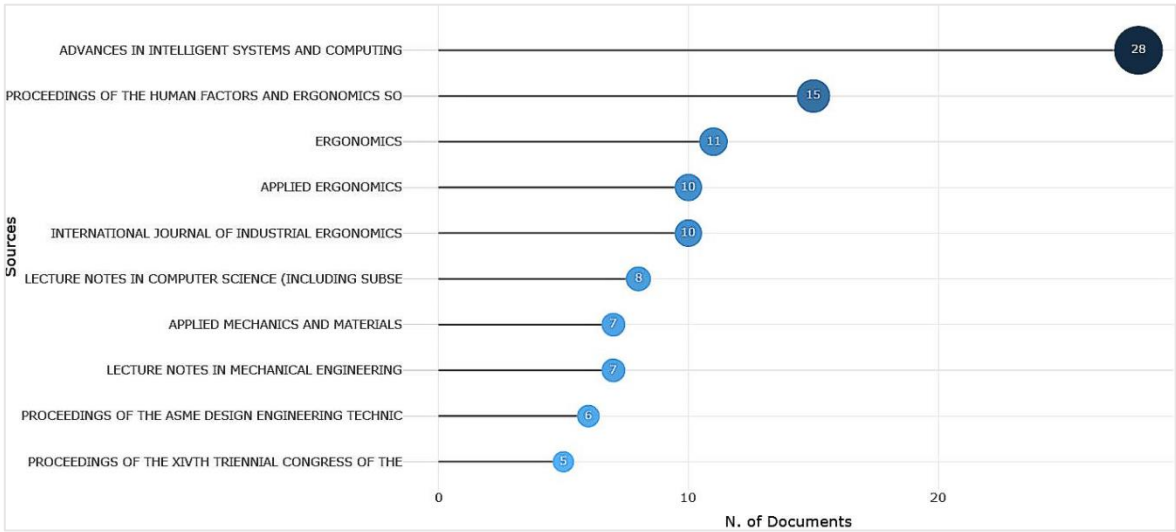

Fig.9. Most relevant publication sources and most globally cited documents in aesthetics and ergonomics research. Core journals such as design studies and applied ergonomics act as interdisciplinary hubs, while the most cited documents emphasize ergonomics as a foundation, with aesthetics gaining increasing scholarly attention. Data extraction date, January 2025

3.2.7. Most global cited documents

Table 7, extracted from R Studio, identifies the top 20 most globally cited documents related to the integration of aesthetics and ergonomics in product design. The table includes the paper titles, DOI links, total citation counts, annual citations (TC per Year), and normalized citation counts (Normalized TC). This provides a comprehensive view of the most influential works in the field. The study by Creusen and Schoormans (2005) published in the Journal of Product Innovation Management ranks as the most cited document with 672 citations and a normalized citation score of 6.73925501. Its annual citation rate (32 TC per year) highlights its continued relevance in the field. The paper by Hsu (2000) from the International Journal of Industrial Ergonomics follows with 332 citations and a strong normalized score (6.56491715). The list includes papers published in prestigious journals such as Applied Ergonomics, Human Factors, and Journal of Product Innovation Management, demonstrating the interdisciplinary nature of the research. This table highlights the foundational and influential works driving research in integrating aesthetics and ergonomics. It identifies key authors, themes, and journals, serving as a guide for future researchers to build on these impactful studies. The high citation rates of older papers indicate that they remain highly relevant, providing theoretical and methodological insights for contemporary research in product design.

Tab.7. 20 most global cited documents

N	Paper	DOI	Total citations	TC per year	Normalized TC
1	Creusen Meh, 2005, J Prod Innovation Manage	10.1111/j.0737-6782.2005.00103.x	672	32	6.73925501
2	Hsu Sh, 2000, Int J Ind Ergon	10.1016/S0169-8141(99)00026-8	332	12.7692308	6.56497175
3	Mcdonagh D, 2002, Appl Ergon	10.1016/S0003-6870(02)00008-X	188	7.83333333	3.38129496
4	Fenko A, 2010, Appl Ergon	10.1016/j.apergo.2009.03.007	175	10.9375	10.4054054
5	Meyer J, 2004, Hum Factors	10.1518/hfes.46.2.196.37335	172	7.81818182	5.03414634
6	Liu Y, 2003, Ergonomics-A	10.1080/00140130310001610829	151	6.56521739	3.83248731
7	Khalid Mh, 2006, Concurrent Eng Res Appl	10.1177/1063293X06068387	130	6.5	8.66666667
8	Burnett Ge, 2001, Int J Hum Comput Stud	10.1006/ijhc.2001.0482	107	4.28	2
9	Han Sh, 2003, Ergonomics	10.1080/00140130310001610928	104	4.52173913	2.63959391
10	Helander Mg, 2003, Ergonomics	10.1080/00140130310001610847	88	3.82608696	2.23350254
11	Mugge R, 2012, Appl Ergon	10.1016/j.apergo.2012.03.009	78	5.57142857	5.09803922
12	Vargas-Mart?N F, 2002, Optom Vis Sci	10.1097/00006324-200211000-00009	75	3.125	1.34892086
13	Schifferstein Hnj, 2007, Ergonomics	10.1080/00140130701524056	72	3.78947368	5.77540107
14	Moon H, 2015, J Prod Innovation Manage	10.1111/jpim.12172	70	6.36363636	4.66666667
15	Bordegoni M, 2013, Virtual Phys Prototyping	10.1080/17452759.2012.762612	68	5.23076923	6.8
16	J??Sk? V, 2003, Proc Int Conf Des Pleasurable Prod Interfaces	10.1145/782924.782927	63	2.73913043	1.59898477
17	Liu Y, 2003, Ergonomics	10.1080/00140130310001610838	61	2.65217391	1.54822335
18	Den Buurman R, 1997, Ergonomics	10.1080/001401397187676	58	2	4.02777778
19	Kanis H, 1998, Appl Ergon	10.1016/S0003-6870(97)00028-8	58	2.07142857	4.75409836
20	Chang H-C, 2007, Int J Ind Ergon	10.1016/j.ergon.2006.09.014	57	3	4.57219251

This analysis also emphasizes the value of interdisciplinary approaches and the importance of publishing in high-impact journals to achieve global recognition and influence.

3.2.8. Summary of findings by research question

Q1. What words and trends are growing in the field?

The results of the keyword analysis displayed a clear distribution of four overarching theme groups: 1. ergonomics and human factors, 2. aesthetics and emotional design, 3. technology and simulation tools, and 4. sustainability and innovation. Ergonomics words did remain as anchors of the network, indicating an important role of stable foundations; aesthetics and sustainability words are growing but less prevalent, and development here illustrates a possible move toward more interdisciplinary collections, with technology and environmental concerns playing a greater future role.

Q2. Which authors are leading in this field?

The co-authorship and citation network analysis revealed a clustering of highly productive and influential authors. These authors have advanced both the means of inquiry as well as theoretical lens to incorporate in design aesthetics with ergonomics. The clustering of authors demonstrates the evolution of regional schools of thought. The actual citation and references reveal core "pivotal" works remain a basis to make connections between newer contributions.

Q3. Which countries have done the most research in this field?

The analysis found China has the most published work and implies significant national investment in design and ergonomics research. However, China's research into did not gain as much international collaboration as the other countries studied. Cooperation within Europe and North America is still prevalent, as reflected by the contributions of USA, UK, and Germany as international collaboration hubs. There are emerging countries, such as Southeast Asia, that are integrating as a more active contributive member of international research which reflects a growing, global reach of the field.

4. Discussion

This section reviews the ten most cited articles. As shown in Table 8, the areas covered in these articles are mostly about product design.

Creusen & Schoormans (2005) in their study, they emphasize the multifaceted role of product appearance in consumer choice. It concludes that aesthetics and symbolism are pivotal in durable, home-visible products, while ergonomic simplicity is equally crucial. The findings underscore the synergy of aesthetic and functional roles in product design, advocating for a balanced approach to meet diverse consumer expectations. Hsu et al. (2000), their research highlights perceptual gaps between designers and users regarding product forms. It concludes that while designers prioritize creativity and sophistication, users lean towards simplicity and delicacy. Bridging this gap through collaborative approaches could lead to designs that resonate better with user preferences. McDonagh et al. (2002) in their paper conclude that user-centered tools like mood boards and product personality profiling are instrumental in capturing emotional responses to products. The integration of these tools into the design process can enhance creativity and align designs with user aspirations. Fenko et al. (2010) reveal shifts in sensory dominance during user-product interactions. It concludes that vision dominates at the purchase stage, but touch and audition gain significance during usage. Designers should consider these sensory shifts to create lasting, engaging product experiences. Meyer (2004) identifies compliance and reliance as critical responses to dynamic hazard warnings. It concludes that decision-making frameworks like expected value analysis can improve the effectiveness of such systems by addressing normative, task, and operator factors comprehensively. Y. Liu (2003) proposes the concept of "engineering aesthetics" to systematically integrate aesthetics into product and system designs. It concludes that this discipline can bridge the gap between artistic appreciation and functional design, leveraging multi-modal and interactive methodologies for innovation. Khalid & Helander (2006) in their study underscores the importance of addressing customer emotions in design, emphasizing the need for cultural sensitivity. It concludes that combining subjective and objective measures can provide deeper insights into emotional responses, enhancing the affective quality of products. Burnett & Porter (2001) their research advocates for incorporating non-visual cues, particularly haptics, in car interfaces. It concludes that insights from visually impaired individuals can inspire novel, user-friendly designs that minimize driver distraction.

Tab.8. Ten most cited documents

N	Researcher and year	Research title	Total citations	Summary	Main findings	Field of study
1	(Creusen & Schoormans, 2005)	The Different Roles of Product Appearance in Consumer Choice	672	The paper identifies and provides evidence for six different roles that product appearance can play in consumer choice: communication of aesthetic, symbolic, functional, and ergonomic information; attention drawing; and categorization.	− The six roles of product appearance (aesthetic, symbolic, functional, ergonomic, attention-drawing, and categorization) were all relevant for consumers in this study, with aesthetic and symbolic roles being the most commonly mentioned. − Aesthetic value was particularly important for durable products that are visible in the home, with the majority of subjects considering aesthetic fit in their product choice. − Usability, particularly the number and size of buttons, was an important consideration for over a third of subjects, with many preferring a small number of buttons for simplicity of operation.	Product design
2	(Hsu et al., 2000)	A semantic differential study of designers' and users' product form perception	332	The paper investigates the differences in product form perception between designers and users, using the semantic differential method to examine the relationship between the subjects' evaluation of telephone samples and form design elements.	− Designers and users perceive the same product form and image words differently. − Users are less clear on the meaning of certain image-words compared to designers, leading to differences in their perceptions. − Designers and users have different conceptual models, with designers valuing "creative," "mature," and "delicate" images, while users are mainly influenced by the "delicate" image, leading to differences in their product preferences.	Product design
3	(McDonagh et al., 2002)	Visual product evaluation: exploring users' emotional relationships with products	188	The paper discusses three techniques that designers can use to elicit users' emotional responses and perceptions of products in order to inform the product design process.	− The paper presents techniques such as product personality profiling, mood boards, and visual product evaluation that can be used to elicit users' emotional responses and perceptions of products beyond just their functional aspects. − These techniques can be used at different stages of the product development process to better understand user needs and aspirations. − Incorporating user research and these techniques into the design process can enhance designers' creativity and lead to more user-centered design.	Product design
4	(Fenko et al., 2010)	Shifts in sensory dominance between various stages of user–product interactions	175	The dominant sensory modality in product experience changes over time, with vision being most important during the buying stage, touch and audition becoming more important during usage, and the relative importance of the different modalities depending on the product's primary function.	− At the time of buying, vision is the most important sensory modality, but during product usage, other modalities like touch and audition become increasingly important. − After one month of usage, touch becomes more important than vision, and after one year, vision, touch, and audition appear to be equally important. − To create a long-lasting positive product experience, designers need to consider user-product interaction at different stages of product usage and determine which sensory modality dominates at each stage.	Product design
5	(Meyer, 2004)	Conceptual issues in the study of dynamic hazard warnings	172	The paper presents a conceptual analysis of dynamic hazard warning systems, distinguishing between compliance and reliance as two forms of responses and identifying determinants of these responses that can be broadly classified into normative, task, and operator factors.	− The paper presents a conceptual analysis of dynamic hazard warning systems and identifies two key types of responses to warnings: compliance (acting according to the warning) and reliance (refraining from action when no warning is given). − The paper identifies various factors that can influence these responses, including normative factors (e.g., probability of failures, payoff structure), task factors (e.g., task structure, interface design), and operator factors (e.g., abilities, training, beliefs about the system). − The paper emphasizes the need to evaluate operator actions in response to warnings using normative decision-making frameworks, such as expected value (EV) analysis, rather than simply categorizing actions as "errors".	Safety

6	(Y. Liu, 2003)	Engineering aesthetics and aesthetic ergonomics: theoretical foundations and a dual-process research methodology	151	The paper proposes the establishment of a new scientific discipline called "engineering aesthetics" that uses engineering and scientific methods to study and incorporate aesthetics into the design and evaluation of products and systems.	– The paper argues that aesthetics should be incorporated as an important dimension in ergonomics and human factors research, and proposes the establishment of a new scientific discipline called "engineering aesthetics" to systematically study aesthetics in human-machine-environment systems. – The paper identifies two special features that distinguish aesthetic appraisal of products and system designs from aesthetic appreciation of art: they tend to be multi-modal and interactive. – The paper proposes a dual-process research methodology for "engineering aesthetics" that combines a "top-down" multidimensional construct analysis and a "bottom-up" psychophysical analysis.	Engineering aesthetics
7	(Khalid & Helander, 2006)	Customer emotional needs in product design	130	The paper discusses the importance of considering customer emotions in product design and presents a framework for analyzing human factors issues within a user-designer relationship to achieve affective design.	– Emotions in product design are culturally and user-specific, so designers need to avoid cultural bias. – -Both subjective and objective measures are needed to evaluate emotions, considering factors like dynamics, context, reliability, validity, and measurement error. – Emotions are important in product design, and many companies now challenge designers to manipulate the emotional impact of their designs.	Product design
8	(Burnett & Porter, 2001)	Ubiquitous computing within cars: designing controls for non-visual use	107	The paper discusses the need for research and development to ensure that control interfaces for future cars require minimal visual demands, and argues that much can be learned from the experience and strategies adopted by people who are blind or have low vision to aid in the development of novel designs.	– There is a need for increased use of haptic (touch-based) cues in the control interfaces of future cars to minimize the visual demands on drivers. – Designers can learn from the experiences and strategies of people who are blind or have low vision to develop novel and usable in-car control interfaces. – Incorporating input from "non-users" (people with visual impairments) can provide valuable insights at the early stages of the design process.	Product design
9	(Han & Hong, 2003)	A systematic approach for coupling user satisfaction with product design	104	The paper proposes a systematic approach for coupling user satisfaction with product design.	– The paper developed relationship models that can predict user satisfaction and guide design changes. – The paper identified critical design features that significantly influence user satisfaction dimensions, and analyzed the common properties of these critical features. – The paper compared the relationship models and critical design features between US and Korean consumers, highlighting both similarities and differences.	Product design
10	(Helander, 2003)	Forget about ergonomics in chair design? Focus on aesthetics and comfort!	88	The paper concludes that while ergonomic design of chairs is important, users have difficulty perceiving differences in ergonomics and discomfort between chairs, and instead tend to favor chairs based on aesthetics, plushness, and a sense of relaxation.	– Chair users had difficulty perceiving differences in comfort and discomfort between different chairs. – Comfort and discomfort should be measured separately, as they are distinct concepts, rather than on a single continuous scale. – Differences in chair design did not significantly affect measures of discomfort, which explains why previous studies have struggled to differentiate between chairs based on ergonomic evaluations.	Product design

Han & Hong (2003) in their study presents a systematic approach to linking user satisfaction with product design. It concludes that identifying critical design features and cultural variations can enhance satisfaction and guide targeted design improvements. Helander (2003) concludes that aesthetics and comfort often outweigh ergonomic considerations in chair design. It highlights the challenges users face in perceiving ergonomic differences and advocates for separate metrics for comfort and discomfort to refine design evaluation. These articles collectively advance the understanding of integrating aesthetics and ergonomics, emphasizing user-centered approaches, emotional engagement, and sensory dynamics to inform innovative product designs.

Although the review of highly cited studies illustrates their contributions as separate works, a more critical synthesis reveals overlapping frameworks and recurring shortcomings. Many of these impactful articles feature a user-centered design perspective and treat ergonomics as the basis, with aesthetics as an extra layer to appeal to users (e.g., Jordan, 2000; Desmet & Hekkert, 2007). Each article shared concern for the relationship between a product's feature-set and a user's associated feelings or usability outcomes. However, there are several limitations: the majority are context-bound (e.g., they focus on products in a category or in a specific cultural

context) and very few articles try to combine aesthetics and ergonomics into a single model that could be tested. There have been competing positions on aesthetics driving initial adoption (with ergonomics sustaining long-term use) or aesthetics and ergonomics being equally important across the entire product lifecycle. This highlights a future research agenda for researchers to design longitudinal studies to understand how this dimension unfolds across time.

5. Conceptual framework for integrating aesthetics and ergonomics

Based on the bibliometric results and synthesis of prior studies, a conceptual framework is proposed to illustrate how aesthetics and ergonomics intersect in product design (Fig. 10). The framework emphasizes three possible modes of integration:

1. Concurrent Co-existence: Aesthetics and ergonomic function are each acknowledged as separate but related aspects of design. Both are inevitably continuous to product development, and may each affect a decision to trade-off balance.
2. Layered Integration: Ergonomic functionality forms the foundation of product usability, upon which aesthetic elements are layered to create emotional appeal, symbolic meaning, and differentiation in the marketplace.
3. Interactive Synergy: Aesthetics and ergonomics dynamically reinforce one another. For example, ergonomic shapes may enhance perceived beauty, while aesthetic cues can guide intuitive interaction and usability. This interactive mode represents the most holistic approach, where visual appeal and functional comfort are co-designed to optimize user experience.
4. The analysis notes that the market-driven product design typically moves toward an interdependent and reinforcing model of interactive synergy of aesthetics and ergonomics. This perspective clarifies the need for design processes that evaluate visual, emotional, and functional dimensions simultaneously, as opposed to treating them as separate and independent concerns.

In addition to the bibliometric evidence, the findings from this study can be connected to larger theoretical and interdisciplinary frameworks. From a design theory viewpoint, the findings validate the idea that products perform better when there is a balance of form and function, which aligns with the traditional idea of "design is a balance of beautiful and usable". The clustering of keywords that focus on user experience and usability shows how ergonomics addresses this balance by providing visual appeal that is facilitated by functional ease and comfort. From an ergonomics perspective, the findings demonstrate that there is an increasing turn toward a human-centered and technology-enabled variety of ergonomics, such as neuroergonomics and digital simulation tools. This transition supports moving away from static physical characteristics to a more dynamic cognitive and affective interaction of the human–product system. Moving ahead of interdisciplinary literature, the emerging themes in artificial intelligence-assisted design and affective computing signify that evidence is being drawn from intersecting fields like design, engineering, psychology, and computer science. It is anticipated that later research on ergonomics and aesthetics will ultimately progress beyond usability and aesthetic appeal but will also assist in fulfilling larger themes around human–technology integration and more sustainable innovation.

While this research identifies foundational studies through the lens of the most cited published work globally, it is critical to review more recent publications over the last 3–5 years. Much of the new research included has potential contributions to the field, but has not been cited highly enough to reflect their importance yet. Much of the new research includes emerging methodologies, technologies, or interdisciplinary perspectives. For example, recent studies have considered the role of AI and machine learning in aesthetic evaluation and ergonomic customization (Burnap et al., 2023). Similarly, the exploration of neuro-ergonomics and EEG-based design evaluation has benefited from the integration of cognitive neuroscience and product design (Jafarnejad Shahri et al., 2024).

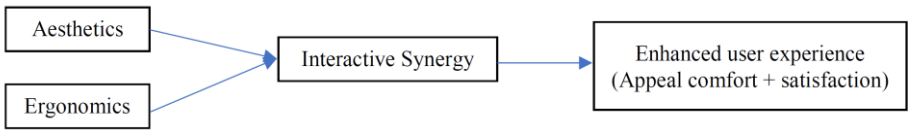

Fig.10. Conceptual framework illustrating modes of integration between aesthetics and ergonomics

Together, these contributions demonstrate that the field is shifting to a more dynamic technology-enabled user-centered approach and highlight directions that may characterize the next research evolution. Therefore, future bibliometric analysis should support highly printed and cited studies with systematic examinations of more recent publications to push toward the additional contributions of foundational work and the evolution of formation in new fields.

6. Policy Implications

The bibliometric results also have implications for policy and research governance. For instance, the analysis found that China contributes the most to overall publication output, but has a lower level of international collaboration. Therefore, policymakers in China might encourage further participation in large, multinational research consortia or collaborative funding. For example, in Europe and North America, there may be potential policy opportunities to foster international collaboration. The keyword analysis also demonstrated that ergonomics-centered terms had significantly more centrality than aesthetics-centered terms, thus supporting the idea that policies are developed to advocate for cross-disciplinary graduate training to create a balance between ergonomics expertise and aesthetic innovation. Such policies would keep usability and emotional engagement at the same level of priority when developing products. Lastly, the identification of emerging themes such as sustainability and emotional design may reveal policy opportunities to blend environmental initiatives into the user-centered design process. For instance, funding-oriented policies could support recent projects that create synergies between sustainable materials, ergonomic performance, and aesthetic appeal. Such policy recommendations advance academic research and practical research in industry to produce functional and attractive products that are environmentally sustainable.

7. Conclusion

The bibliometric data reveal a significant global effort to integrate ergonomics and aesthetics in product design. China is a leading hub for research, while European countries provide deep specialization in usability and emotional design methodologies. Collaboration among countries and authors across continents presents an opportunity for expanding interdisciplinary research, particularly in emerging regions like India and Brazil. This visualization effectively highlights the interconnectedness of themes, geographies, and individual contributions, providing a comprehensive overview of the research landscape on integrating aesthetics and ergonomics in product design. In addition, the analysis indicates a rising global interest in integrating aesthetics and ergonomics since 2000, with the USA and China being the dominant contributors. The increasing involvement of countries like Malaysia reflects a growing interest in design research, driven by regional demands and academic development. The findings suggest that the integration of aesthetics and ergonomics is not only a growing trend but also an area that requires further exploration. The study identifies gaps in the literature, indicating that while interest is rising, comprehensive studies that systematically explore the intersection of these domains are still lacking. The research reveals that authors from different countries exhibit diverse thematic focuses, underscoring the interdisciplinary nature of the field. This diversity can lead to innovative approaches in product design that effectively combine aesthetic appeal with ergonomic functionality. These conclusions collectively emphasize the importance of integrating aesthetics and ergonomics in product design and highlight the dynamic and evolving nature of research in this multidisciplinary area.

8. Limitations and Future Studies

This study has several limitations which must be acknowledged: first, the study was based solely on the Scopus bibliometric data. Although Scopus offers extensive coverage of design, ergonomics and engineering research, it may exclude valuable contributions published in regional or non-indexed journals. It could be overcome by combining several sources, such as ScienceDirect and Google Scholar, and including regional or non-English publications to achieve a broader coverage. Second, this study is limited to publications in 2025, omitting newer developments and trends in the integration of aesthetics and ergonomics. Future investigations could use real-time citation tracking and AI-assisted bibliometric tools to capture ongoing and recent trends in the field. Third, the bibliometric procedures of the study

present a robust view of the contexts of aesthetics and ergonomics that exist, but they do not give us a sufficient qualitative depth to understand the complex relationship between the two, influenced by particular cultural methods and milieux. With this shortcoming, new studies could be undertaken combining bibliometric techniques with qualitative approaches, using case studies, expert interviews or content analysis, in order to explore the discursive and context-related capabilities of this relationship. Association of the cited journals and hence of those cited. Lastly, the current research gives no consideration to the quality or methodological rigour of the articles analyzed. Any future study taking into account these criteria would help to increase the reliability of bibliometric indicators and give a sound analysis of disciplinary impact.

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