LOKUM Sanat ve Tasarım Dergisi
Journal of Art and Design

e-ISSN: 2980-0722, Çevrimiçi/Online, https://dergipark.org.tr/tr/pub/lokum
Cilt / Volume: 4, Sayı / Issue: 1, 2026

THE FORMATION OF SCHOLARLY KNOWLEDGE AND ACADEMIC INFRASTRUCTURE IN DESIGN STUDIES (1979–2025)

Tasarım Çalışmalarında Akademik Birikimin ve Bilimsel Altyapının Oluşumu (1979–2025)

Onur Aşkın[1]

Article Information

Research Article

Received:
May 16, 2026
Accepted:
June 22, 2026
Published:
August 25, 2026

Keywords:
Bibliometrics,
Canon formation,
Citation analysis,
Collaboration network,
Design studies

Abstract

Over more than four decades, Design Studies has done more than document design research; it has contributed to the formation of a scholarly structure that shapes which questions gain visibility, which authors become central, and which geographies participate in knowledge production. This study applies a single-journal bibliometric analysis to the journal's complete publication archive from 1979 to 2025. Using a dataset comprising all research articles published in the journal (n = 1,347 articles; 71,102 citations), the study analyses citation networks, co-authorship networks, co-citation keywords, and thematic bigrams through a Python-based analytical framework, incorporating concentration measures such as the Gini coefficient and Herfindahl–Hirschman Index (HHI). The findings reveal three interconnected patterns: the emergence of a stable theoretical core centred on influential scholars, an unequal citation structure consistent with canon formation (Gini = 0.676; the top 10% of articles account for 14.7% of all citations; mean citations = 52.79; median = 23), and a gradual transition from individual scholarship to collaborative and institutionally embedded research production. The rise of design thinking discourse after 2011 also indicates thematic expansion into management and innovation contexts, while scholarly production remains concentrated within Western institutional centres. Drawing on Star and Ruhleder's (1996) concept of infrastructure, these patterns are interpreted as evidence of a self-reinforcing academic publishing ecosystem. The study argues that canon formation in design research functions as an infrastructural process and offers a framework linking bibliometrics with the sociology of scientific knowledge.

Makale Bilgisi

Araştırma Makalesi

Gönderilme:
16 Mayıs 2026
Kabul:
22 Haziran 2026
Yayın:
25 Ağustos 2026

Anahtar kelimeler:
Atıf analizi,
Bibliyometri,
İş birliği ağı,
Kanon oluşumu,
Tasarım çalışmaları

Özet

Kırk yılı aşkın bir süre boyunca Design Studies dergisi yalnızca tasarım araştırmalarını belgelemekle kalmamış, aynı zamanda hangi soruların görünürlük kazandığını, hangi yazarların alanın merkezine yerleştiğini ve hangi coğrafyaların bilgi üretimine katıldığını belirleyen akademik bir yapının oluşumuna katkıda bulunmuştur. Bu çalışma, derginin 1979–2025 yılları arasındaki tüm yayın arşivini inceleyen tek dergi odaklı bir bibliyometrik analiz sunmaktadır. Scopus veritabanından elde edilen ve dergide yayımlanan tüm araştırma makalelerini kapsayan veri seti (n = 1.347 makale, 71.102 atıf), atıf ağı, ortak yazarlık ağı, ortak atıf kümeleri ve yoğunlaşma göstergeleri (Gini katsayısı, HHI) ile bigram tabanlı tematik analizi içeren, yeniden üretilebilir bir Python tabanlı işlem hattıyla analiz edilmiştir. Bulgular, birbiriyle ilişkili üç temel örüntü ortaya koymaktadır: etkili araştırmacılar etrafında şekillenen istikrarlı bir kuramsal çekirdek, kanon oluşumuyla ilişkili eşitsiz bir atıf yapısı (Gini katsayısı = 0,676; ilk %10'luk makalelerin toplam atıfların %14,7'sini alması; ortanca atıf = 23, ortalama atıf = 52,79) ve bireysel akademik üretimden kurumsal ve işbirlikçi araştırma modeline doğru gerçekleşen yapısal dönüşüm. 2011 sonrasında tasarım odaklı düşünme söyleminin yükselişi, alanın yönetim ve inovasyon bağlamlarına doğru tematik olarak genişlediğini gösterirken, akademik üretimin büyük ölçüde Batılı kurumsal merkezlerde yoğunlaşmaya devam ettiği görülmektedir. Çalışma, Star ve Ruhleder'in (1996) altyapı kavramından hareketle bu örüntüleri kendini yeniden üreten bir akademik yayıncılık ekosisteminin göstergesi olarak yorumlamaktadır. Sonuç olarak çalışma, tasarım araştırmalarında kanon oluşumunun altyapısal bir süreç olduğunu savunmakta ve bibliyometri ile bilim sosyolojisini ilişkilendiren bir analitik çerçeve önermektedir.

Kaynak Cite : Aşkın, O. (2026). The formation of scholarly knowledge and academic infrastructure in design studies. *Lokum Journal of Art and Design, 4*(2), 248-268.

İntihal Plagiarism : Bu makale, en az iki hakem tarafından incelenmiş ve yayın öncesi intihal taraması yapılmıştır. This article has been reviewed by at least two reviewers and checked for plagiarism before publication.

[1] Asist. Prof. Dr, Doğuş University, oaskin@dogus.edu.tr, ORCID: 0000-0002-1928-474X

INTRODUCTION

Over the last forty-five years, design research has been institutionalized as a unique scientific field at the intersection of architecture, engineering, industrial design, cognitive psychology, and management sciences.

Bibliometric methods make the intellectual structure of a discipline visible through quantitative analysis of publication counts, citation patterns, author networks, and thematic trends. Behind the numbers lie sociological and epistemological questions: which theoretical questions gain legitimacy, which intellectual communities take shape, and which geographies participate in knowledge production.

Examining Design Studies from this perspective is important for understanding how design research has become a scientific field. To this end, the study is structured around four main research questions:

RQ1: How have the theoretical and methodological foci evolved over time in Design Studies?

RQ2: Which are the journal's most influential publications, and which thematic clusters do they represent?

RQ3: What is the distribution of author collaborations and geographical production, and how has this changed over time?

RQ4: How can the discipline's conceptual orientations reflect in titles, abstracts, and keywords be read through bigram extraction and period-level thematic analysis?

This paper argues that Design Studies exhibits patterns consistent with the scientific infrastructural functions described by Star and Ruhleder (1996) as an invisible yet constructive system that enables certain practices and frames knowledge production. The journal may not only have published research but also produced a visibility ordering of what counts as design research.

Infrastructure is operationalized here through three functions: (i) standardization, establishing a repertoire of legitimate questions and methodologies; (ii) selectivity, creating a comparable corpus through editorial filtering; (iii) measurable visibility, the circulation of certain texts through citation and co-citation networks. These functions serve as the reading framework throughout the Results section, with each indicator explicitly linked to its corresponding function.

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Historical Development and Theoretical Foundations of Design Research

Design research gained an academic identity in the 1960s with the design methods movement. Early self-criticism by Alexander (1971) and Jones (1977) rejected mechanistic algorithmization of design, opening space for Rittel and Webber's (1973) "wicked problems," Simon's (1969) scientific framing of design activity, and Schön's (1983) concept of "reflection-in-action." These two references sit in productive tension: Simon treated design as a rational, rule-governed problem-solving activity that could in principle be formalized and optimized, whereas Schön rejected this positivist premise, arguing that designer's reason through situated, tacit judgment that resists full codification. The juxtaposition is intentional rather than contradictory it signals that the design methods movement of this period was already internally divided between a scientific-rationalist and a reflective-practitioner account of design activity, a division

that subsequent design cognition research, including the present bibliometric analysis, continues to register.

Design Cognition and Protocol Studies

This subsection is retained at this level of detail because design cognition subsequently emerges in the Results as one of the journal's two dominant thematic clusters (Section 4.4); the methodological lineage outlined here (protocol analysis, the DTRS series, and the FBS ontology) is therefore directly relevant to interpreting the bigram and topic-modelling output reported below, rather than constituting unrelated theoretical background. Design cognition examines how designers think, process information, and make decisions. Empirical studies rely largely on protocol analysis, in which designers think aloud during the design process and their verbal output is systematically coded (Ericsson & Simon, 1984). The DTRS series (Cross, Christiaans, & Dorst, 1996) was central to standardizing this methodology, while Dorst and Cross (2001) developed a problem-solution co-evolution model from protocol data. Goldschmidt (1991, 2014) contributed through studies on sketching and visual thinking, and the Function-Behavior-Structure (FBS) ontology (Gero & Kannengiesser, 2004; Gero & Milovanovic, 2020) provides a formal model of the design process.

The Interdisciplinary Nature of Design Research

Design research is inherently interdisciplinary. Friedman (2003) categorizes its knowledge base across natural sciences, humanities, social sciences, arts, technology, and practical disciplines, while Christensen and Ball (2019) show that Design Studies has both expanded into new sub-disciplines and maintained conceptual integration over four decades. This interdisciplinarity is directly relevant to the present study's infrastructural argument: for a single journal to function as Star and Ruhleder's (1996) infrastructure, it must perform the boundary-spanning work of absorbing heterogeneous knowledge bases-cognitive science, social science, engineering, and the arts into a coherent and citable disciplinary canon. The breadth documented by Friedman (2003) and the conceptual stability documented by Christensen and Ball (2019) are therefore read here as preconditions for, rather than incidental features of, the standardizing function the journal is argued to perform.

Application of Bibliometric Methods to Design Studies

Bibliometric analysis maps the intellectual structure of a field through citations, keywords, co-authorship, and institutional affiliations (Donthu et al., 2021; Zupic & Čater, 2015), using tools such as CiteSpace (Chen, 2006) and VOSviewer (van Eck & Waltman, 2010). Chai and Xiao (2012) showed that design processes and design cognition are the two main themes in Design Studies (1996–2010), while Dragčićević et al. (2023) traced the evolution of design thinking in both academic and applied contexts. Chai and Xiao (2012) remain the closest precedent to the present study, yet their analysis is limited to a fifteen-year window (1996–2010) and to thematic content, without addressing citation inequality, network centrality, authorship structure, or geographic distribution. The present study extends this line of inquiry by covering the journal's complete publication history (1979–2025), more than three times the period analysed by Chai and Xiao, and by integrating concentration metrics (Gini, HHI, Top-k shares), co-citation and collaboration network analysis, and bigram-based thematic tracking within a single infrastructural framework. This combination of full-archive coverage and multi-method canon-formation analysis constitutes the gap the present study addresses.

METHOD

This study examines publication production, citation impact, authorship, and thematic orientations of Design Studies (1979–2025) via a reproducible Python pipeline (Pandas/NumPy, scikit-learn, NetworkX).

Data cleaning followed a three-step flow: raw Scopus export (n = 1,552) → document type filtering (research articles only) Editorials, book reviews, errata, and conference abstracts were excluded because they are not subject to the same peer-review and citation conventions as research articles, and their inclusion would distort citation-based concentration metrics (Gini, HHI, Top-k shares) that assume a comparable population of substantively reviewed contributions. → duplicate removal, yielding a final sample of n = 1,347. The analysis period is divided into five sub-periods: 1979–1990, 1991–2000, 2001–2010, 2011–2020, and 2021–2025. The first interval spans twelve years (1979–1990) rather than ten because the journal published a small number of issues per year immediately after its founding in 1979; combining this start-up phase into a single period avoids sub-periods with too few articles to support stable concentration and network statistics. The final interval is correspondingly shorter (2021–2025) because it is bounded by the data collection date rather than by a fixed ten-year span. For the last interval, citation indicators should be interpreted with caution, given Scopus indexing lag. Authorship patterns were operationalized by parsing the semicolon-delimited author strings in the Scopus "Authors" field.

Thematic analysis combined the title, abstract, and author keyword fields. During bigram extraction, copyright-notice artifacts originating from the journal website were removed in the pre-processing stage. To ensure that fragile steps did not unduly influence results, three robustness controls were applied: (1) stability testing of bigram/theme results at different Top-N and minimum-frequency thresholds; (2) cohort-window citation reporting (3- and 5-year windows); (3) self-citation sensitivity analysis at the author and journal level. All three controls produced findings consistent with the main analysis. The five thematic categories reported in the Results (design research, design cognition, creativity, engineering design, and design thinking) were derived through a hybrid procedure rather than purely manual or purely automated coding: bigrams and keyword clusters were first extracted algorithmically from the title, abstract, and keyword fields, after which the resulting clusters were manually labelled and consolidated against established design-research taxonomies (e.g., Cross, 2018; Chai & Xiao, 2012) to avoid near-duplicate or overly granular categories. Geographic attribution followed standard bibliometric convention: each article was assigned to the country of the first (corresponding) author's institutional affiliation as listed in the Scopus record, regardless of the number of co-authors. This first-author convention is a simplification for multi-author, multi-country teams and is noted as a limitation in the Methodological Limitations subsection.

RESULTS

Publication and Citation Trends

A total of 1,347 research articles were published in Design Studies between 1979 and 2025. Table 1 summarizes publication counts, total citations, and mean citations per article across the five analytical periods (Figure 1).

Table 1. Publication and citation statistics by period (1979–2025)

Period	Number of publications	Total citations	Mean citations per article
1979–1990	316	6,167	19.52
1991–2000	262	16,933	64.63
2001–2010	275	26,062	94.77
2011–2020	359	19,950	55.57
2021–2025	135	1,990	14.74

Note. Citation figures for 2021–2025 should be interpreted cautiously due to Scopus indexing lag.

The founding period (1979–1990) shows modest mean citations consistent with publication lag. The 2001–2010 period marks the citation peak at 94.77 per article, with the low values for 2021–2025 attributable primarily to indexing lag rather than lower impact.

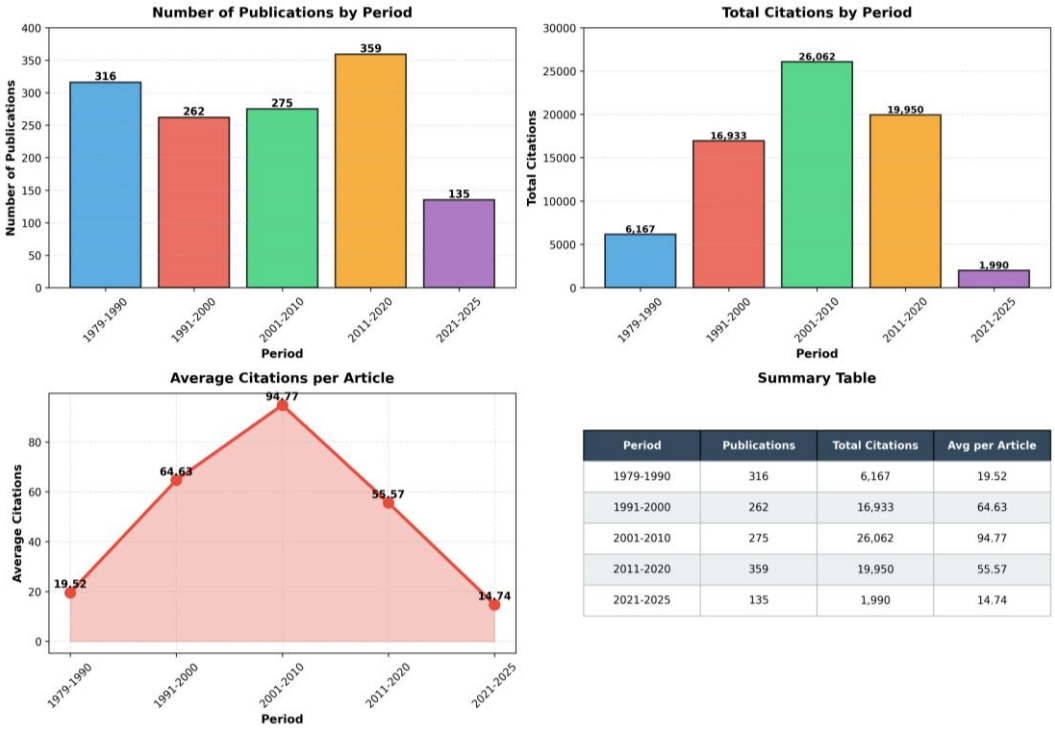


Figure 1. Publication and citation statistics by period (1979–2025).

Most Influential Texts and the Theoretical Core

From an infrastructural perspective, the most-cited publications reveal which concepts have become the field's "lingua franca." Table 2 lists the 15 most-cited articles; age-normalized impact scores are in Figure 2.

Table 2. Top fifteen most cited articles (1979–2025)

Year	Title	Author(s)	Citations
2001	Creativity in the design process: Co-evolution of problem-solution	Dorst, K.; Cross, N.	1,884
2011	The core of 'design thinking' and its application	Dorst, K.	1,373
1991	Design fixation	Jansson, D.G.; Smith, S.M.	1,240
2003	Metrics for measuring ideation effectiveness	Shah, J.J.; Vargas-Hernandez, N.; Smith, S.M.	1,091
2004	The situated function-behavior-structure framework	Gero, J.S.; Kannengiesser, U.	1,077

1982	Designerly ways of knowing	Cross, N.	1,035
2004	Seeing things: Consumer response to the visual domain in product design	Crilly, N.; Moultrie, J.; Clarkson, P.J.	786
2016	Evolution of design for sustainability: From product design to design for system innovations and transitions	Ceschin, F.; Gaziulusoy, I.	708
1992	Kinds of seeing and their functions in designing	Goldschmidt, G.	675
2008	Describing the creative design process by the integration of engineering design and cognitive psychology	Dinar, M. et al.	618
2000	A heuristic method for identifying modules for product architectures	Stone, R.B.; Wood, K.L.; Crawford, R.H.	583
1997	What do architects and students perceive in their design sketches? A protocol analysis	Suwa, M.; Tversky, B.	505
2002	Thinking in design teams: An analysis of team communication	Valkenburg, R.; Dorst, K.	478
1996	Design and other types of fixation	Purcell, A.T.; Gero, J.S.	475
2009	Biologically inspired design: process and products	Helms, M.; Vattam, S.S.; Goel, A.K.	450

Dorst and Cross's (2001) joint study (1,884 citations) conceptualized design creativity as a problem-solution co-evolution. Cross's (1982) "Designerly Ways of Knowing" (1,035 citations) provided an epistemological foundation for design research. Gero and Kannengiesser's (2004) function-behavior-structure framework (1,077 citations) provided an ontological model for design cognition. Dorst's (2011) "The core of design thinking" ranks highest by age-normalized citation score (91.53 per year), indicating rapid uptake consistent with the post-2011 expansion of design thinking discourse. The remaining eleven entries cluster into three recognizable strands of the theoretical core. A design-fixation strand comprises Jansson and Smith (1991) and Purcell and Gero (1996), the foundational and extending studies on how prior examples constrain idea generation. A protocol-and-cognition strand comprises Goldschmidt (1992) on sketching and visual reasoning, Suwa and Tversky (1997) on architects' sketch protocols, Valkenburg and Dorst (2002) on team communication, and Dinar et al. (2008) on integrating engineering design with cognitive psychology, together extending the Cross–Gero theoretical axis identified above. A methods-and-engineering-design strand comprises Shah, Vargas-Hernandez, and Smith (2003) on ideation metrics, Stone, Wood, and Crawford (2000) on modular product architecture, and Helms, Vattam, and Goel (2009) on biologically inspired design, reflecting the journal's parallel engineering-design lineage. Ceschin and Gaziulusoy (2016) is the only entry from the post-2011 period and anticipates the tentative sustainability signal discussed in the Discussion section. Crilly, Moultrie, and Clarkson (2004) stands apart from all three strands: rather than addressing the designer's process or cognition, it examines consumer perception of product appearance, drawing on marketing and visual-cognition literatures rather than the design-methods tradition. Its presence in the theoretical core indicates that high citation status in Design Studies is not confined to studies of the design process itself, but can also be achieved by research that imports an adjacent disciplinary perspective into the journal's scope a finding that qualifies, rather than undermines, the canon-formation argument advanced here.

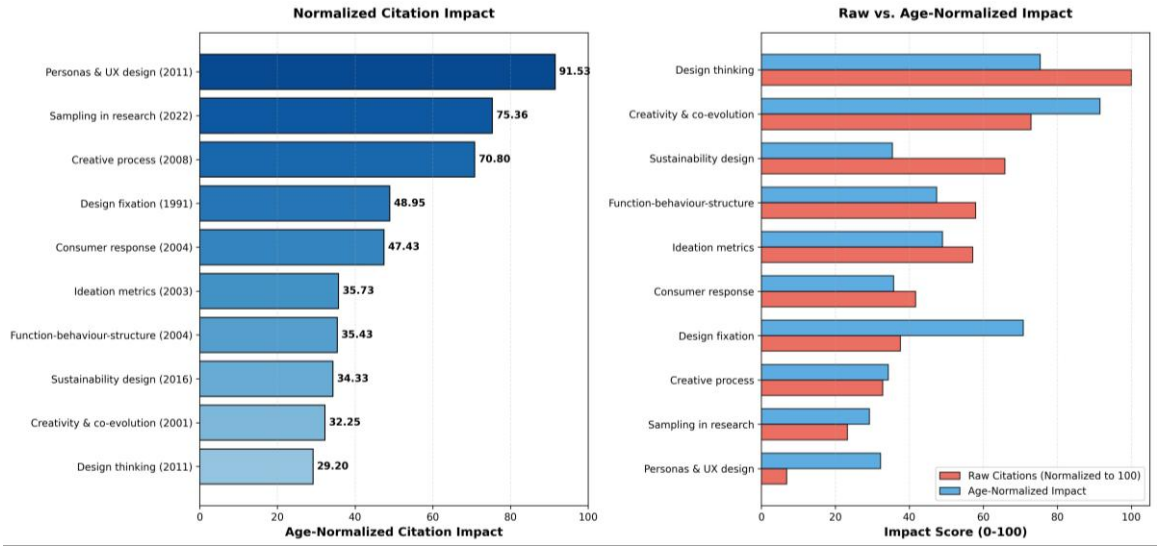


Figure 2. Age-normalized citation impact scores for Top 10 articles.

Authorship Patterns and the Rise of Collaboration

The shift to multi-authorship can be read as an infrastructural trace: the proliferation of labor-intensive methodological standards in design research (e.g., protocol analyses, multivariate quantitative methods, large-scale computational studies) has contributed to a research norm that is increasingly difficult to sustain through single author work alone. Table 3 summarizes authorship patterns across the five periods (Figure 3).

Table 3. Authorship patterns by period

Period	Single-authored (%)	Mean number of authors
1979–1990	74.7%	1.33
1991–2000	44.7%	1.84
2001–2010	29.1%	2.27
2011–2020	20.9%	2.86
2021–2025	16.3%	3.09

Single-authored publications declined from 74.7% in 1979–1990 to 16.3% in 2021–2025, while the mean number of authors rose from 1.33 to 3.09. The most prolific contributors to the corpus are Gero, J.S. (20 publications), Cash, P. (17), and Cross, N. (17), followed by Dorst, K. (15) and Crilly, N. (14) (Figure 4). The two authors tied at 17 publications differ markedly in publication period: Cross's contributions are distributed across nearly the full archive (1979–2018), consistent with a sustained, career-long presence in the journal, whereas Cash's 17 publications are concentrated almost entirely in the 2011–2025 sub-periods. This indicates that Cash's prominence reflects a recent and comparatively rapid rise in productivity rather than a long-standing equivalent presence to Cross, a distinction relevant to interpreting authorship-based centrality as a static rather than time-varying measure. The co-authorship network comprises 1,857 authors across 392 independent components, indicating both the breadth of the field and the persistence of loosely connected sub-communities (Figures 5 and 6).

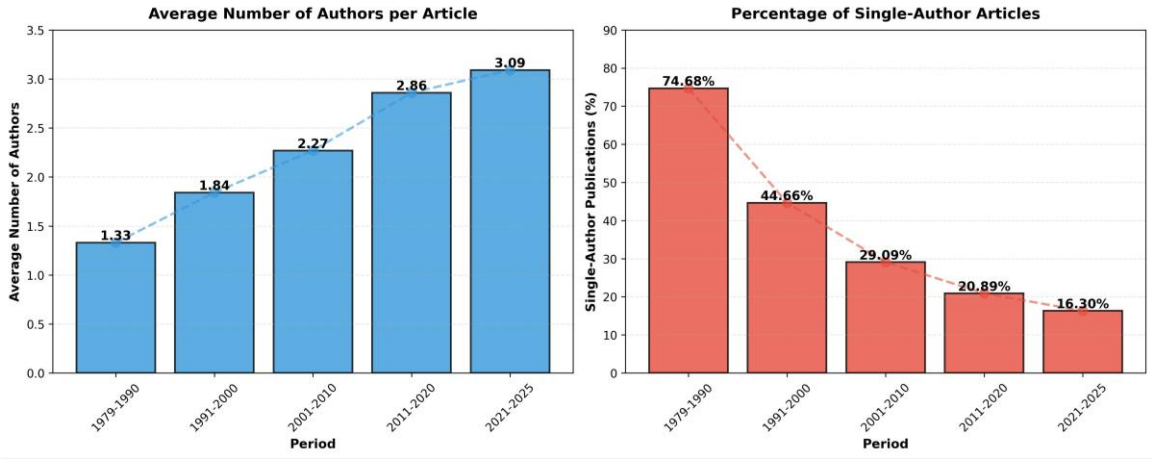


Figure 3. Authorship trends by period (1979–2025).

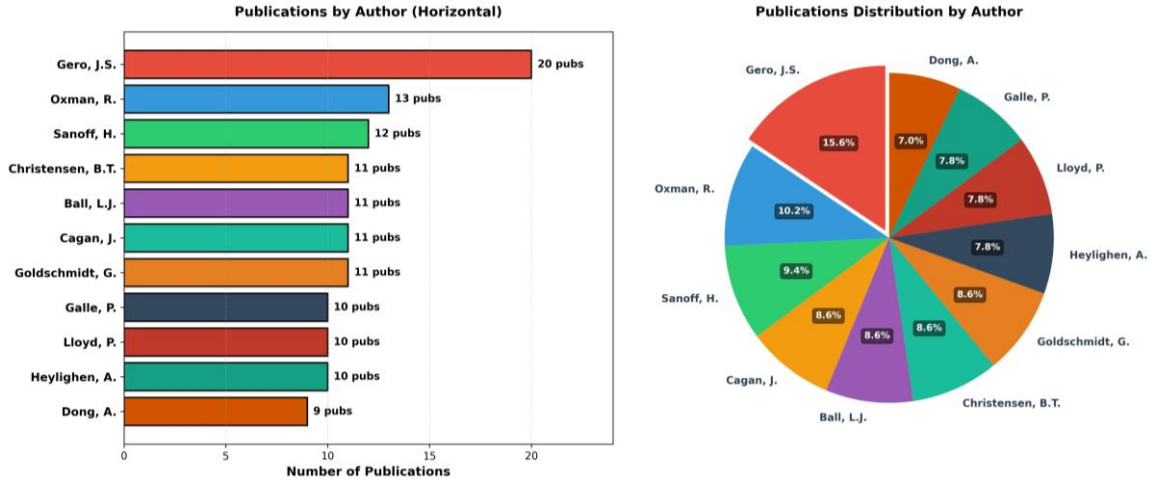


Figure 4. Most productive authors by publication count.

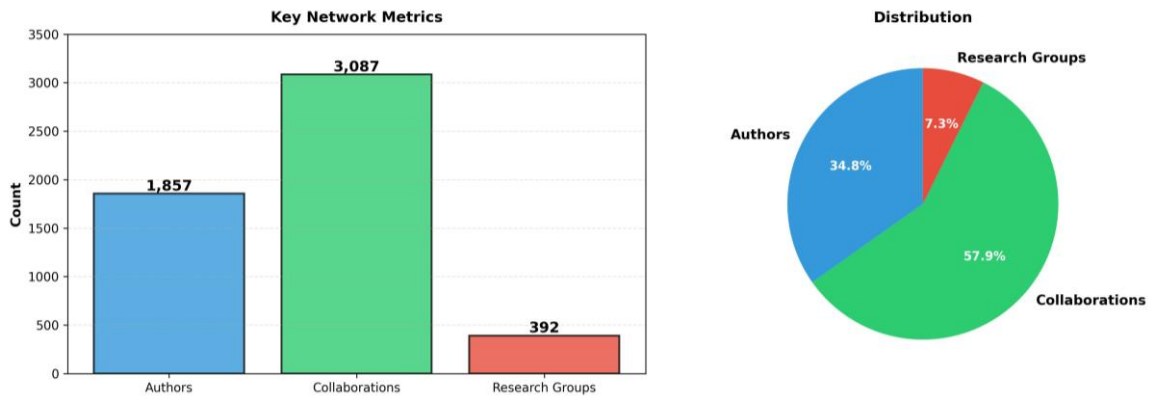


Figure 5. Co-authorship network key metrics.

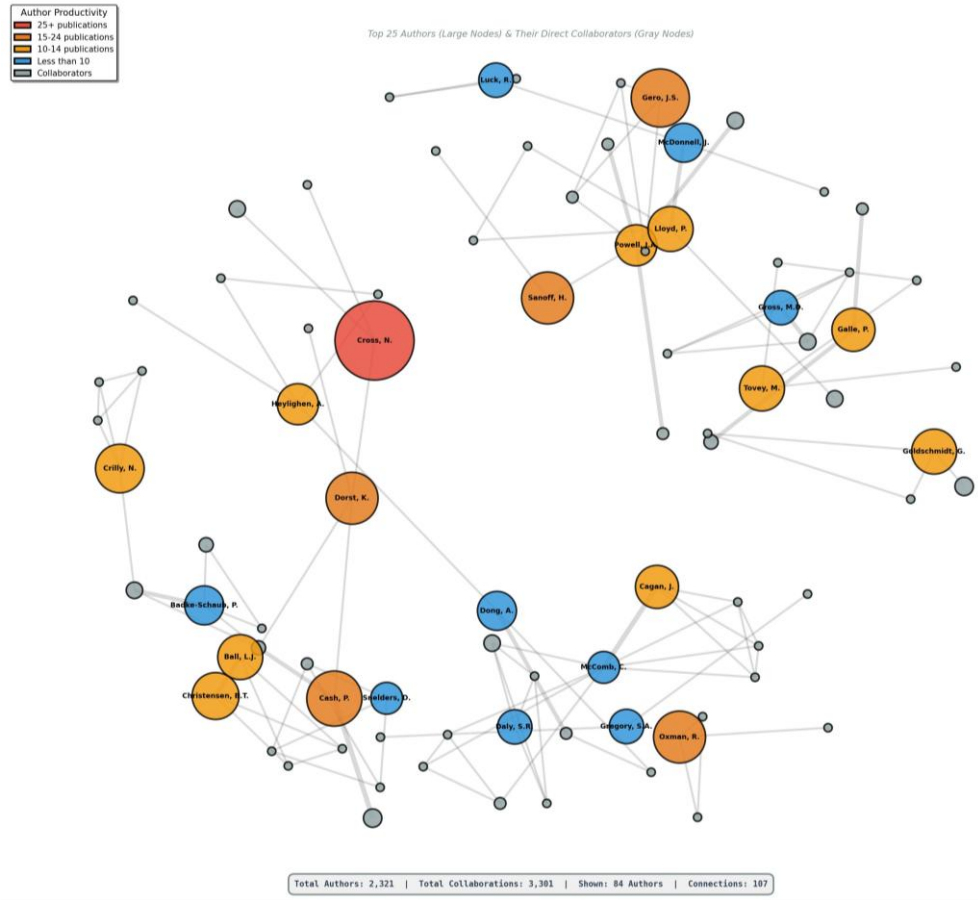


Figure 6. Author collaboration network Design Studies (1979–2025). Top 25 authors (large nodes) and their direct collaborators (gray nodes).

Evolution of the Conceptual Repertoire

Thematic analysis was conducted combining title, abstract, and author keyword fields, supported by bigram extraction and a period × theme matrix. The approach goes beyond classical keyword co-occurrence to present a "conceptual repertoire" reading, making thematic change comparable not only as a frequency list but also as a period orientation. As detailed in the Method section, the five theme groups reported below were derived through a hybrid procedure algorithmic bigram/keyword clustering followed by manual labelling and consolidation against established design-research taxonomies rather than by keyword frequency alone. Table 4 summarizes the five main theme groups across the full corpus (Figure 9). Top keywords and bigrams are visualized in Figures 7 and 8; thematic distributions are shown in Figures 9 and 10.

"Design research" is the most dominant theme with 241 articles, followed closely by "design cognition" (225). The most diagnostic trend is the rise of "design thinking" (59 articles), which is concentrated almost entirely in the post-2011 period (Table 4; Figure 9). At the bigram level, "design process" is by far the most frequent term (470 occurrences), while "design thinking" (112) shows a clear temporal cluster in recent years. This shift can be read not as a discursive fashion change alone, but as a structural signal that the infrastructure has expanded its visibility capacity into management, innovation, and organizational contexts.

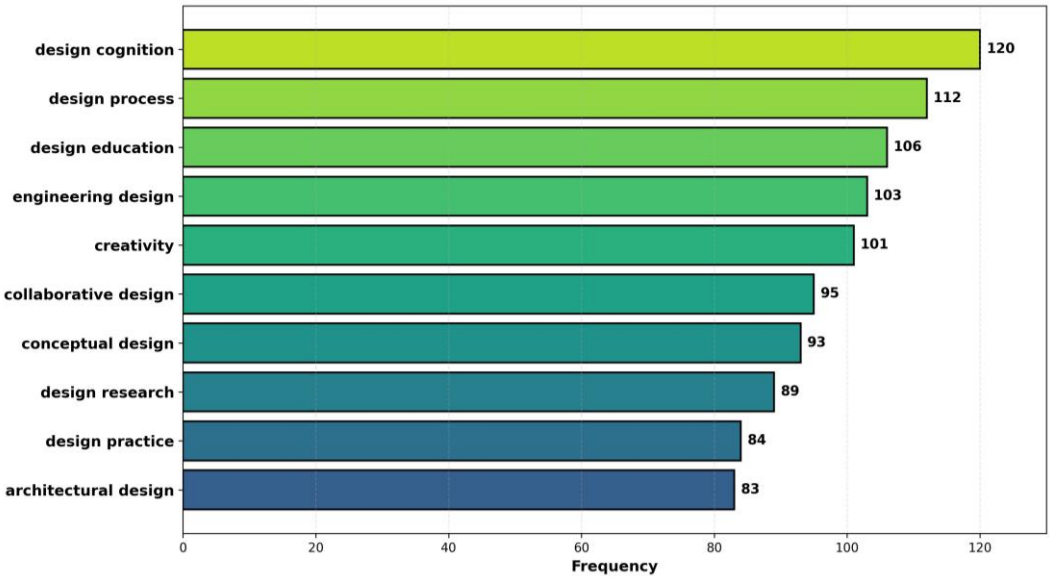


Figure 7. Top ten keywords in Design Studies (1979–2025).

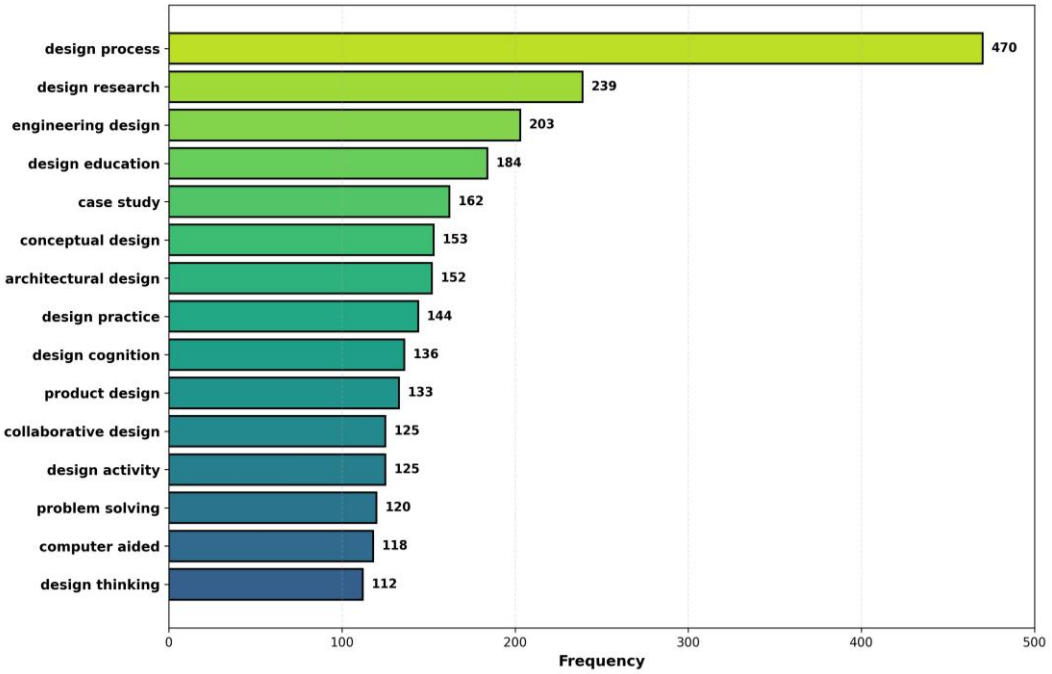


Figure 8. Top fifteen bigrams (two-word phrases) in Design Studies (1979–2025).

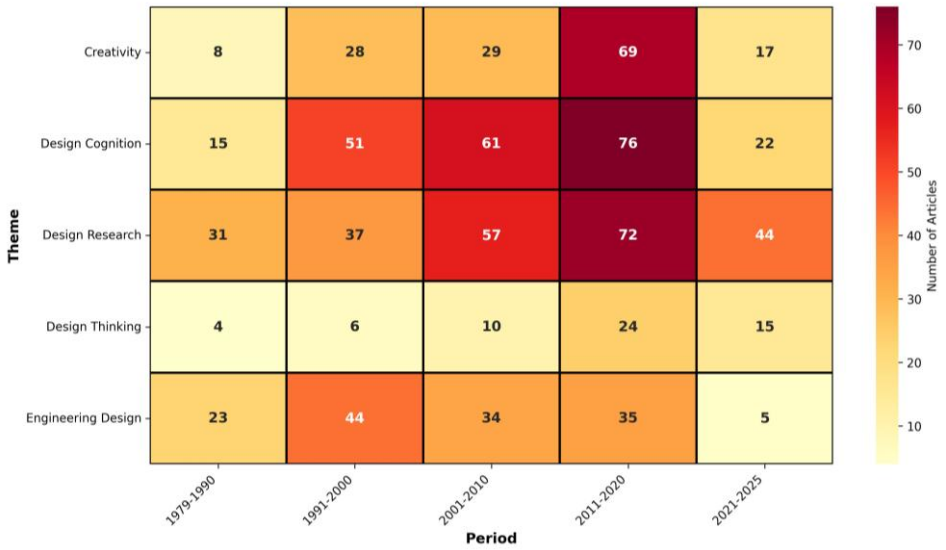


Figure 9. Theme × period matrix article counts by theme group.

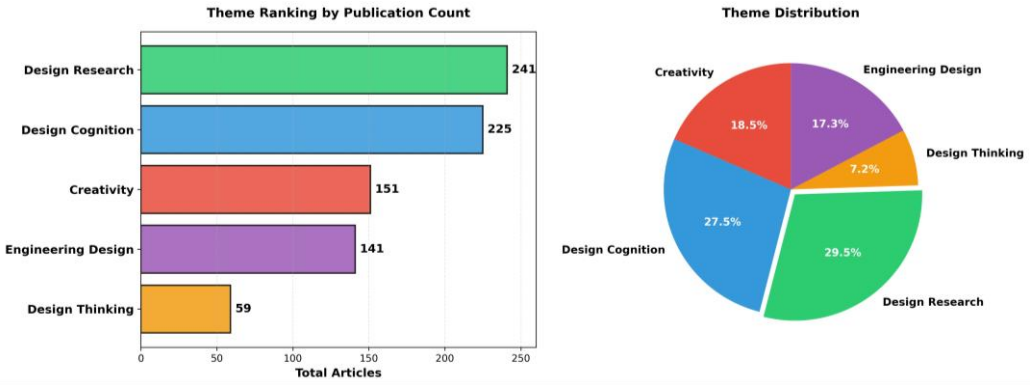


Figure 10. Research theme distribution summary Design Studies (1979–2025).

Table 4. Period × theme matrix: article counts by theme group

Theme	Total articles (n)	Note
Design research	241	Most dominant theme across the corpus
Design cognition	225	Consistent presence across all periods
Creativity	151	Stable mid-range presence
Engineering design	141	Strong in early periods; relatively stable
Design thinking	59	Marked rise after 2011

Geographic Distribution of Scholarly Production

Country-level affiliation data, extracted via text matching from the Scopus export, shows that the United Kingdom, the United States, the Netherlands, Australia, and Sweden account for the majority of publications across all five periods. While the 1979–1990 founding period is almost entirely dominated by UK and US affiliations, subsequent decades show incremental diversification, with growing contributions from continental Europe, East Asia, and, more recently, the Global South. Contributions from Africa, South Asia, and Latin America remain substantially underrepresented throughout the

corpus. Contributions from Africa, South Asia, and Latin America remain comparatively underrepresented throughout the corpus. The geographic distribution presented in Figure 11 shows that publication output remains concentrated in a small group of countries led by the United Kingdom, United States, Netherlands, Australia, and Sweden. Country-level distribution is visualized in Figure 11, and the collaboration network in Figure 12. These findings should be interpreted cautiously, given parsing noise in affiliation string matching.

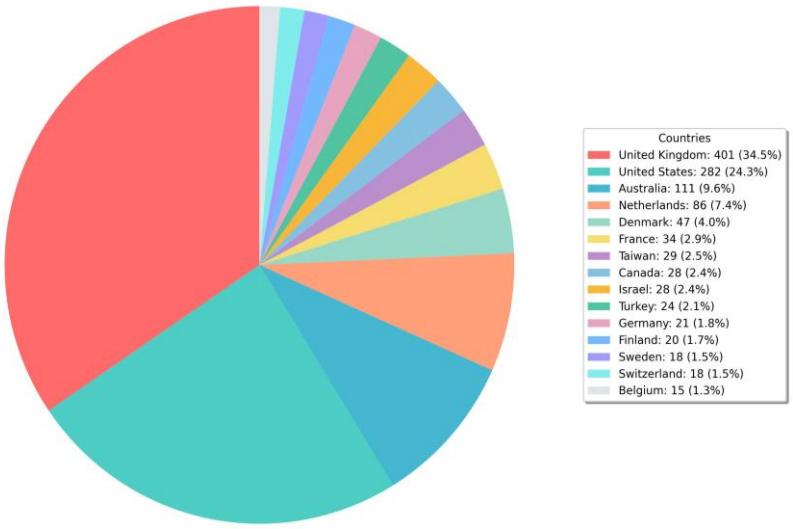


Figure 11. Geographic distribution of scholarly production, top fifteen countries by publication count.

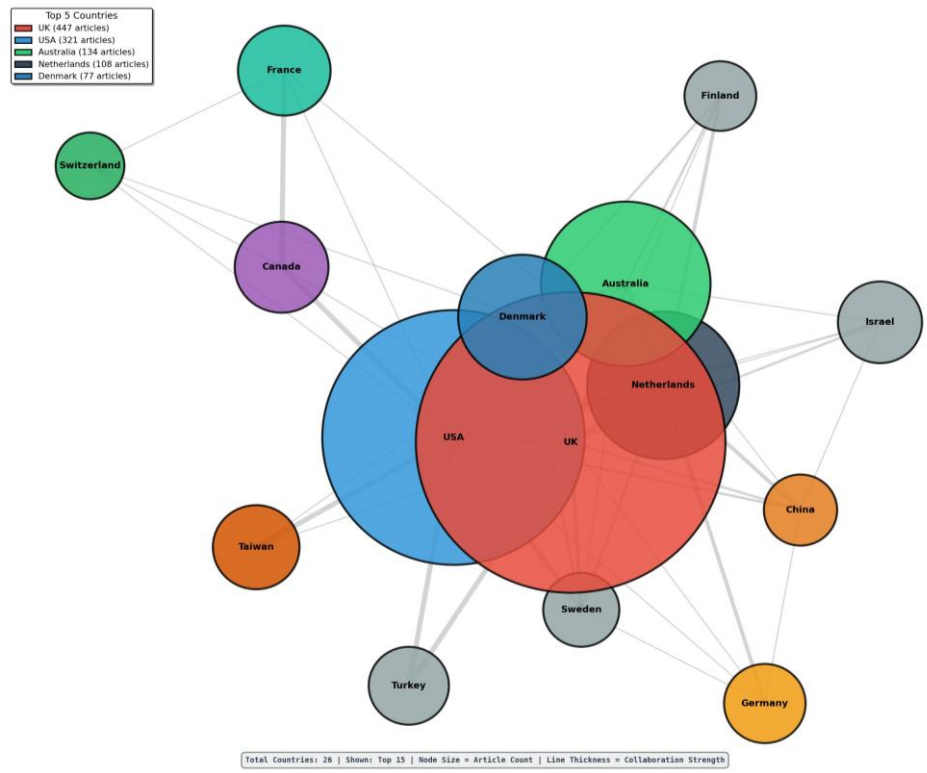


Figure 12. Country Collaboration Network Design Studies (1979–2025). Node size = article count; line thickness = collaboration strength.

Citation Concentration and Canon Formation

Citation inequality metrics provide quantitative traces of the journal-infrastructure's capacity to systematically select and promote certain ideas, texts, and authors. Table 5 summarizes the key concentration indicators.

Table 5. Citation inequality metrics

Metric	Value
Total articles	1,347
Total citations	71,102
Mean citations per article	52.79
Median citations	23
Gini coefficient	0.676
Top 10% share	14.7%
Top 20% share	21.2%
Top 50% share	32.9%
HHI (Herfindahl-Hirschman)	0.0042

The Gini coefficient of 0.676 indicates a high degree of concentration. This value is high in absolute terms but is also broadly consistent with citation Gini coefficients reported for single-journal and discipline-level corpora elsewhere in the bibliometrics literature, where values in the 0.6–0.8 range are common; it should therefore be read as evidence of a typically skewed citation distribution rather than as an exceptional or unique degree of concentration specific to this journal. The median citation is 23 while the mean is 52.79, indicating a right-skewed distribution in which a small number of high-impact articles pull the mean upward. The Top 10% of articles account for 14.7% of all citations, and the Top 50% for 32.9%. Taken on its own, the 14.7% Top-10% share is moderate rather than extreme relative to citation-concentration norms reported in other fields, where the top decile frequently accounts for a comparable or larger share of citations; this figure should therefore be read as qualified rather than unambiguous support for the canon-formation argument, and is interpreted jointly with the Gini coefficient and network-centrality evidence below rather than in isolation. The Herfindahl-Hirschman Index (HHI = 0.0042), although originally developed for market-concentration analysis in economics, is reported here only as a convergent, scale-independent check on the Gini and Top-k results: an HHI in this range corresponds to a citation market with no single article commanding outsized individual share, which is consistent with concentration being distributed across a theoretical core of multiple texts (Table 2) rather than a single dominant outlier. Co-citation pairs with unresolved or incomplete reference matching ("undefined" records) were excluded from the centrality calculations reported below. This exclusion is reported so that the network-based findings can be evaluated for potential coverage bias. These metrics operationalize canonization through three converging signals: (i) citation inequality (Gini, Top-k shares, HHI), (ii) citation network centrality (identifying bridge texts), and (iii) co-citation cluster structure. It should be emphasized that these are indicators of citation concentration, not direct measures of canonical status: a text can be highly cited without functioning as a canonical reference (e.g., as a methods citation rather than a conceptual touchstone), and the inference to canon formation drawn throughout this study rests on the convergence of citation concentration with network centrality and co-citation clustering, not on citation count alone.

Reference Canon and Co-Citation Structure

The following tables summarize the journal's core literature structure, based on standardized source names extracted from reference lists. Strings that could not be parsed or normalized were labeled as “undefined” and excluded from the tables below; findings in this section should therefore be considered exploratory. Reference normalization was conducted using a rule-based pipeline validated against a semi-manually compiled canonical dictionary (n ≈ 30 core works).

Table 6. Most frequently cited sources in reference lists (undefined excluded)

Reference (normalized)	Doc.	Total
Design Issues	65	76
Developments in Design Methodology	46	55
The Sciences of the Artificial	43	43
Design Studies	38	38
Analyzing Design Activity	36	40
Engineering Design	35	38
Engineering Design Methods	30	30
Designing Engineers	30	30
An ethnographic perspective on engineering design (Bucciarelli)	26	26
Psychology of Architectural Design	26	26
Notes on the Synthesis of Form	25	25
Sketches of Thought	25	25
Environment and Planning B: Planning and Design	22	25
Emerging methods in environmental design and planning	22	24
How designers think	20	20

Table 7. Co-citation network centralities top 10 (undefined excluded)

Reference (normalized)	PageRank	Betweenness	Doc. Frequency
Design Issues	0.0132	0.0837	65
Developments in Design Methodology	0.0102	0.0221	46
Analyzing Design Activity	0.0087	0.0297	36
Design Studies	0.0081	0.0401	38
The Sciences of the Artificial	0.0075	0.0316	43
Designing Engineers	0.0068	0.0321	30
Engineering Design Methods	0.0067	0.0297	30
Designing in the Wild (Ball)	0.0064	0.0198	23
Engineering Design	0.0061	0.0155	35
Bucciarelli: An ethnographic perspective…	0.0059	0.0219	26

Table 8. Co-citation communities

Community	Size	Featured references (PageRank order)
1	227	Developments in Design Methodology; Analyzing Design Activity, The Sciences of the Artificial
2	190	Design Studies; Designing in the Wild, Design Issues
3	155	Design Issues; Cross/Dorst clusters (record fragmentation dense)
4	86	Agonistic participatory design; Co-design; Participatory design
5	83	Designing Engineers; Bucciarelli; Engineering Design Methods
6	28	Benefits and costs of investment in design…
7	22	Ecological approach to visual perception; On the nature of design…
8	4	Metaphors we live by; Metaphor and thought

Design Issues ranks highest in both document frequency and PageRank, serving as the primary bridge node. The Sciences of the Artificial (Simon, 1969) and Developments in Design Methodology confirm the stability of the Cross–Dorst–Gero core. Eight communities were identified: the two largest were anchored by foundational methodology and cognition texts, while Communities 4 and 5 represented participatory and engineering design sub-traditions. These patterns are consistent with a publishing ecosystem in which editorial orientations and citation concentrations have remained mutually reinforcing, rather than a causal claim of single-handed canon construction.

DISCUSSION

The bibliometric profile of Design Studies provides interpretable indicators of disciplinary institutionalization, suggesting the journal functions as a publishing ecosystem that mediates visibility through publication agendas and citation circulation.

Theoretical Canon and Intellectual Infrastructure

The citation analysis confirms concentration on the Cross–Dorst–Gero axis. Cross's (1982) "Designerly Ways of Knowing" provided an epistemological foundation, Gero and Kannengiesser's (2004) FBS framework an ontological model, and Dorst and Cross's (2001) co-evolution study a widely adopted creativity theory. Beyond simply confirming this concentration, the practical implication is that these three texts function as obligatory points of passage for subsequent work: their recurrence across citing articles, regardless of sub-field, suggests that engagement with this axis has become a tacit condition of legibility within the journal, shaping how new contributions must be framed in order to be read as relevant Design Studies scholarship rather than as adjacent disciplinary work. When read through Star and Ruhleder's (1996) infrastructural approach, the findings are consistent with the interpretation that the journal functions as an "infrastructural" publishing ecosystem that standardizes not only the published output but also the repertoire of methods, concepts, and problems.

Methodological Maturation and Institutional Structure

The shift from single-author to multi-author publications (Table 3; Figures 3–6) reflects increasing methodological sophistication in design research. Labor-intensive methodologies such as protocol analysis, multivariate quantitative methods, and large-scale computational studies have made solo scholarship progressively harder to sustain, a trend plausibly associated with institutional developments including PhD programs, research funding, and dedicated design research centers. These institutional factors are not directly measured in this study no editorial, funding, or program-level data were collected and should therefore be read as a plausible explanation for the observed authorship pattern rather than as a finding the data establish.

Thematic Evolution and Interdisciplinary Expansion

Bigram and keyword analyses (Table 4; Figures 7–10) reveal a clear shift in intellectual orientation. Early dominance of "design methods" and "engineering design" gave way post-2011 to "design thinking" and "systematic review," signalling the field's expansion into management and innovation contexts and a growing drive to consolidate accumulated knowledge. The rise of "systematic review" as a keyword, concentrated almost entirely in the post-2011 sub-periods, is consistent with two non-exclusive explanations that the present bigram data cannot fully adjudicate between: an internally driven consolidation of an increasingly large body of accumulated design research findings, and an externally driven adoption of methodological norms imported from

evidence-synthesis traditions in adjacent fields such as management and health sciences, where systematic review methodology is more institutionally established. Distinguishing between these explanations would require tracing citation links from systematic-review articles in Design Studies to methodological sources outside the design research literature, which falls outside the scope of the present bibliometric analysis but is noted here as a direction for future work. A related but more tentative observation concerns sustainability: this term does not constitute one of the five main thematic categories reported in Table 4, and the bigram and keyword data alone do not support describing it as a major thematic expansion. The single indication available is bibliometric rather than topic-modelled: Ceschin and Gaziulusoy's (2016) sustainability-oriented design article appears among the fifteen most-cited texts in the corpus (Table 2), which is suggestive of growing relevance but does not, on its own, establish sustainability as a structural theme on a par with the five categories identified through the thematic analysis. This observation is therefore reported as a single-article signal warranting future, more targeted investigation, rather than as an established thematic-expansion finding.

Citation Structure and Mechanisms of Canonization

The Gini coefficient of 0.676 indicates a high degree of concentration in the citation distribution (Table 5), a pattern broadly typical of single-journal citation distributions and plausibly, though not directly, related to the journal's editorial line, methodological convergence, subject cycles, and citation practices factors this study does not measure directly and which remain candidate mechanisms rather than demonstrated causes. The median citation count of 23, compared with the mean of 52.79, reflects a right-skewed distribution in which a small number of high-impact texts inflate the average, a pattern consistent with, though not on its own sufficient to prove, the interpretation that gaining visibility at this journal tends to require engagement with the established theoretical core; the Top 10% share of 14.7% is moderate rather than extreme by cross-disciplinary standards and is read here as one converging indicator among several (Gini, HHI, network centrality, co-citation structure) rather than as independent confirmation of canon formation.

Geographic Inequality and Participation Structure

Scholarly production in Design Studies has historically been concentrated in Western centres (Figures 11–12) the UK, USA, Netherlands, Australia, and Sweden, a pattern this study documents directly through country-affiliation data rather than inferring from disciplinary-structure literature; Friedman (2003) and Christensen and Ball (2019), cited earlier in this paper, document the interdisciplinary breadth and conceptual integration of design research but do not themselves analyse geographic or regional representation, and are therefore not cited as direct evidence for the geographic pattern reported here; this pattern is consistent with the broader pattern of Anglo-American dominance in English-language academic journals documented in the sociology-of-science and bibliometrics literature more broadly. While incremental diversification is visible from the 1990s onward, contributions from Africa, South Asia, and Latin America remain substantially underrepresented, indicating that the journal's visibility-generation function has historically amplified certain geographic voices while others remain peripheral.

Methodological Limitations

Bibliometric methods reveal macro-level structure but cannot explain causal mechanisms. Citation counts indicate influence without explaining how it is realized;

thematic analysis was constrained by incomplete keyword coverage and the absence of full-text access; geographical inference depends on affiliation string matching and is subject to parsing noise. A further limitation concerns reliance on a single bibliographic database: all records were drawn from Scopus, and alternative databases such as Web of Science have different journal-coverage policies, reference-parsing conventions, and indexing lags, any of which could produce somewhat different citation counts, concentration metrics, or co-citation structures if replicated on a different source. Geographic attribution is also limited by the first-author convention described in the Method section: assigning each article to a single country based on the corresponding author's affiliation understates the contribution of co-authors based in other countries, particularly in the more recent, more collaborative sub-periods, and may therefore understate rather than overstate geographic diversification in later years. All findings are therefore treated as converging exploratory indicators rather than causal explanations.

Disciplinary Maturation and Further Perspectives

The findings converge on several dimensions of institutionalization: theoretical canonization around the Cross–Dorst–Gero core; methodological standardization of protocol analysis and FBS ontology; growth of institutional infrastructure, team-based collaboration; and an early, single-article signal of possible future relevance for sustainability that does not yet rise to the level of a confirmed structural theme. These patterns raise ongoing questions about theoretical openness, geographic inclusion, and the balance between practical accessibility and academic rigor.

CONCLUSION

This study presents a single-journal bibliometric profile of Design Studies (1979–2025), assessing performance, inequality, network, and thematic indicators across 1,347 articles and 71,102 citations, based on a Scopus export and analysed with reproducible Python code.

Addressing RQ1, the findings show periodic reweighting of the conceptual repertoire: early dominance of "design methods" and "engineering design" gave way post-2011 to "design thinking," while "design cognition" and "design process" persisted throughout as a stable theoretical kernel.

Addressing RQ4 specifically, the bigram-extraction and period × theme matrix method developed for this study makes two distinct contributions beyond the RQ1 finding above: it identifies the post-2011 rise of "systematic review" as a separate and methodologically significant pattern from the design-thinking shift, since the two terms peak in different sub-periods and reflect different drivers (thematic expansion versus methodological consolidation, discussed in the Discussion section); and it demonstrates that a conceptual-repertoire reading of bigrams can detect period-specific reweighting that a static keyword-frequency count would not distinguish. This methodological contribution treating thematic change as a period-indexed matrix rather than a single ranked list is reported here as a result in its own right, separable from the substantive RQ1 finding it is used to support.

Addressing RQ2, the most-cited articles and co-citation centralities converge on the Cross–Dorst–Gero axis (Table 2; Tables 6-8; Figure 2). Citation concentration is high (Gini = 0.676; a value broadly typical of single-journal citation distributions; Top 10% share = 14.7%, moderate rather than extreme relative to citation-concentration norms reported in other fields; median = 23), and these indicators, jointly considered,

are consistent with the interpretation that canonization operates as a measurable mechanism rather than constituting direct confirmation of it on their own, as reflected in inequality metrics, network centralities, and co-citation community structure.

Addressing RQ3, authorship patterns reveal a marked shift from single-author to multi-author production (Table 3; Figures 3–6), consistent with the proliferation of labor-intensive methods and computational approaches. The geographical analysis (Figures 11–12) provides an exploratory indication of production concentration in certain centers and structural differences in visibility; given the affiliation-parsing noise and first-author attribution convention noted in the Methodological Limitations subsection, these geographic findings should be read descriptively, as a documented pattern in this single journal's authorship record, rather than as a sociological explanation of the mechanisms producing it.

Together, the findings support the argument that Design Studies operates as a disciplinary infrastructure producing standardization, selectivity, and visibility not as the sole shaper of the field, but as a node structuring the circulation of legitimacy and offering a replicable reading scheme linking bibliometrics to the sociology of design research. This infrastructural and legitimacy-circulation reading is an interpretive synthesis of the bibliometric indicators reported above; it is not itself an empirically tested causal model, since the study does not directly observe editorial decision-making, peer-review processes, or reader behavior. Moreover, because the analysis is based on a single journal, the claim that Design Studies functions as a disciplinary infrastructure should be understood as a single-journal finding that is suggestive of, but does not by itself establish, infrastructural dynamics at the level of the design research discipline as a whole; substantiating the discipline-level claim would require comparable bibliometric analyses of other major design research journals, which this study identifies as a priority for future comparative work rather than claims to have demonstrated.

The study's principal theoretical contribution is the operationalization of Star and Ruhleder's (1996) infrastructure concept developed for information systems and organizational settings as a framework for reading single-journal bibliometric indicators sociologically, treating citation concentration, network centrality, and co-citation clustering jointly as traces of an infrastructure's standardizing function rather than analyzing them as independent bibliometric outputs. Methodologically, the study contributes a reproducible Python pipeline that integrates concentration metrics (Gini, HHI, Top-k shares), citation and co-authorship network analysis, and a period × theme bigram matrix within a single replicable workflow, offering a template that future single-journal or comparative multi-journal studies in design research and adjacent fields can adapt directly.

Building directly on the limitations identified above, three concrete directions for future research follow. First, comparative bibliometric analyses across multiple design research journals (e.g., Design Issues, Journal of Engineering Design, International Journal of Design) would test whether the infrastructural patterns documented here for Design Studies generalize to the discipline as a whole or are specific to this journal's editorial history. Second, replicating the present analysis using Web of Science or a multi-database merge, rather than Scopus alone, would establish whether the concentration and centrality findings are robust to database-coverage differences. Third, given that geographic attribution here relies on a first-author

convention, future work could draw on full-author affiliation data and alternative concentration metrics (e.g., country-level fractional counting) to test whether the apparent geographic concentration narrows once all co-authors' affiliations, not only the first author's, are taken into account.

Limitations determine the level of assertion: single data source (Scopus), citation latency, the approximate nature of affiliation/country inference, and differences in keyword coverage across years. Results should therefore be interpreted as exploratory signals rather than causal explanations.

Ethical Principles

This study was conducted solely through bibliometric data, publication records, and openly accessible academic metadata and does not involve human participants, experimental procedures, or personal data. Therefore, ethical committee approval was not required for this study.

Contribution Rate of the Researchers

The study was prepared by a single author.

Statement of Conflict of Interest

There are no personal or financial conflicts of interest related to this study.

Artificial Intelligence (AI) Commitment



During the preparation of this article, DeepL-assisted language editing tools were used solely for grammar correction, spelling, and language refinement purposes. Artificial intelligence tools were not used for data analysis, interpretation, the generation of scientific results, or the production of research findings. The author assumes full academic, ethical, and scientific responsibility for the entire content of the manuscript.

REFERENCES

Darling, K. (2021). The new breed: what our history with animals reveals about our future with robots. Henry Holt and Company.

Deierlein, A. L., Grayon, A. R., Zhu, X., Sun, Y., Liu, X., Kohlasch, K., & Stein, C. R. (2022). Personal care and household cleaning product use among pregnant women and new mothers during the covıd-19 pandemic. *International Journal Of Environmental Research and Public Health*, *19*(9), 5645

Ellsworth, J. B. (2015). Early adopters. In J. M. Spector (Ed.), The SAGE Encyclopedia of Educational Technology: Vol. 1 (pp. 243-245). Thousand Oaks, CA: Sage Publications.

Fink, J., Bauwens, V., Kaplan, F., & Dillenbourg, P. (2013). Living with a Vacuum Cleaning Robot: A Six-Month Ethnographic Study. *International Journal of Social Robotics, 5*(3), 389–408.

Forlizzi J, DiSalvo C (2006). Service robots in the domestic environment: a study of the Roomba vacuum in the home. In: Proceedings of the ACM/IEEE conference on human-robot interaction 2006, Salt Lake City, Utah, USA, pp 265–285

Hendriks, B., Meerbeek, B., Boess, S., Pauws, S., & Sonneveld, M. (2011). Robot vacuum cleaner personality and behavior. *International Journal of Social Robotics*, 3, 187-195.

Hisahara, H., Ishii, Y., Ota, M., Ogitsu, T., Takemura, H., & Mizoguchi, H. (2014). Human Avoidance Function for Robotic Vacuum Cleaner through Use of Environmental Sensors: Roomba® Making Way for Humans. *5th International Conference on Intelligent Systems, Modelling and* Simulation (ss. 64-67). IEEE.

Kramer, J., & Scheutz, M. (2007). Development environments for autonomous mobile robots: A survey. *Autonomous Robots*, 22, 101-132.

Li, A., Kacprzak, D., & Hu, A. P. (2022). Wireless charger design of robot vacuum cleaners with power repeaters for high compatibility. *Journal of Electromagnetic Analysis and Applications*, 14(5), 47-64.

Önal, O. (2022). *Investigating user experiences with domestic service robots through metaphors: The case of robot vacuum cleaners*. [Unpublished Master's thesis], Istanbul Technical University.

Prassler, E., Ritter, A., Schaeffer, C., & Fiorini, P. (2000). A short history of cleaning robots. *Autonomous Robots, 9*, 211-226.

Quigley, M., Gerkey, B., Conley, K., Faust, J., Foote, T., Leibs, J., Berger, E., Wheeler, R., & Ng, A. Y. (2009). ROS: An Open-source Robot Operating System. *IEEE International Conference on Robotics and Automation Workshop on Open Source Software*. IEEE.

Rapa, C. I., Dephtios, E., Mariangga, C., & Patiung, N. (2022). A design and build a robot vacuum cleaner. *Journal of Physics*: Conference Series Vol. 2394(1), p. 012024. IOP Publishing.

Rogers, E. M. (2003). Diffusion of innovations (5th eşd.). New York, NY: Free Press.

Park, K., & Jung, E. C. (2022). How can humans and robots live together?: The 5 types of human-robot relationship. In International Conference on Intelligent Human Computer Interaction (pp. 225-229). Cham: Springer Nature Switzerland.

Surry, D. W. (2015). Predicting change and adoption of technology innovations. In J. M. Spector (Ed.), The Sage Encyclopedia of Educational Technology: Vol. 2. (pp.584-587). Thousand Oaks, CA: Sage Publications.

Straub, E. T. (2009). Understanding technology adoption: Theory and future directions for informal learning. *Review of Educational Research, 79*(2), 625-649.

Sung J, Grinter RE, Christensen HI (2010). Domestic robot ecology: an initial framework to unpack long-term acceptance of robots at home. *Int J Soc Robot* 2:417–429

Ulrich, I., Mondada, F., & Nicoud, J. D. (1997). Autonomous vacuum cleaner. *Robotics and Autonomous Systems*, 19(3-4), 233-245.

Ulsmåg, B. A. (2023). *Private ınformation exposed by the use of robot vacuum cleaner in smart environments* [Unpublished Master's thesis], Norwegian University of Science and Technology.

Wellendorf, K., Søilen, K., & Veel, K. (2022). Calm surveillance in the leaky home: living with a robot vacuum cleaner. Automating Visuality: The Image Beyond Representation, edited by Dominique Routhier, Lila Lee-Morrison, and Kathrin

Maurer. Special issue, *MAST: The Journal of Media Art Study and Theory*, 3(1), 41-62.

Yapıcı, N. B. (2022). *The effect of human-robot interaction on design and use process of home robots*. [Unpublished Doctoral dissertation], Izmir Institute of Technology.

Zeng, Z., Chen, P. J., & Lew, A. A. (2020). From high-touch to high-tech: COVID-19 drives robotics adoption. *Tourism Geographies, 22*(3), 724-734.