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REVIEW ARTICLE

Paradigm Shifts in Design Thinking: A Scientometric Review

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ABSTRACT

This study investigates the paradigm shift in design thinking from a user-centered operational methodology to a complex socio-technical framework supporting systemic innovation and sustainable development. Using CiteSpace-based bibliometric and knowledge mapping techniques, we analyzed 318 high-quality articles indexed in the Web of Science Core Collection (2015–2024). Our findings reveal a clear three-phase evolutionary trajectory: from tool-centric education and service design applications, through the development of organizational dynamic capabilities, to the recent emphasis on system-wide co-creation and sustainability-oriented innovation. Cluster analysis identifies core knowledge domains, emerging trends in ethical AI co-design, and agile–design hybrid approaches. We further propose a three-dimensional theoretical model integrating cognitive, organizational, and technological perspectives. This work contributes to the theoretical understanding of design thinking's evolving identity and offers practical implications for education, management strategy, and sustainable socio-technical system transformation.

Contribution/Originality: This study contributes to the existing literature by mapping paradigm shifts in design thinking. This study uses new estimation methodology with CiteSpace. This study originates a three-dimensional paradigm framework. This study is one of very few studies which have integrated bibliometric evidence with theoretical analysis.

1. Introduction

Design thinking originated in the fields of industrial design and architectural design (Auernhammer & Roth, 2021). It was initially proposed as a user-centered innovation method emphasizing prototype iteration and problem reframing (Piłat, 2024). Since the beginning of the 21st century, with the development of information technology and the accelerated integration of interdisciplinary fields, the application boundaries of design thinking have expanded rapidly, becoming an indispensable methodology in product

development, service innovation, business strategy, and even social transformation (Piłat, 2024). Its core philosophy is to apply design principles to non-design problems to stimulate innovation and systemic solutions, thereby enabling its widespread penetration into multiple fields such as education, management, healthcare, and government, making it a highly researched subject in both academic and practical circles worldwide (Foundation et al., 2021; Wang C, 2024; Wang X, 2024). As theory deepens and practice expands, design thinking has evolved from an"operational process tool" (such as the five-step method of Empathize–Define–Ideate–Prototype–Test) into a complex paradigm that integrates cognitive logic, organizational capabilities, and social value orientation (Verganti et al., 2021). This transformation not only signifies an enhancement of its functionality but also reflects a shift from the "methodological level" to the "paradigmatic level" (Glushchenko, 2023), positioning design thinking as a new framework for describing, guiding, and even constructing innovative practices and knowledge production (Dell'Era et al., 2020).

Although "design thinking" has gained widespread attention globally as a cross-disciplinary approach to fostering innovation, several key issues regarding its theoretical foundations, practical application pathways, and evolutionary mechanisms remain unresolved. These issues manifest in the following areas: First, inconsistencies between conceptual evolution and theoretical core. Current academic and practical definitions of "design thinking" exhibit diverse characteristics (Auernhammer & Roth, 2023; Micheli et al., 2019), ranging from IDEO and Stanford D.school's "five-stage model" (Zhang, 2020) to the ten core characteristics proposed by Carlgren et al. (2013), all of which reflect the complexity and evolutionary nature of design thinking in terms of cognitive dimensions and implementation pathways (Verganti et al., 2021). This conceptual generalization and ambiguity (Worwood & Plucker, 2017) necessitates the use of systematic bibliometric methods to identify the evolutionary trends and knowledge clusters of its core paradigms. Additionally, research on its paradigmatic foundations, evolutionary processes, and academic development patterns remains insufficient (Bhandari, 2023; Micheli et al., 2019; Tham, 2022). Existing research has primarily explored the application outcomes and model evolution of design thinking from the perspectives of case analysis or empirical summarization (Cai et al., 2023; Retna, 2019). However, there remains a lack of systematic analysis based on bibliometric methods regarding whether design thinking has undergone a paradigm shift in academic research, whether its internal knowledge structure has experienced fragmentation or integration, and how its research focus has evolved over time (Bhandari, 2023; Leal Filho et al., 2024). Especially in the context of continuous challenges from new technologies and new contexts such as artificial intelligence, sustainable development, and complex system design, whether design thinking still has theoretical vitality and how its core components respond to changes in the times (Saeidnia & Ausloos, 2024) have become important issues. Additionally, the dynamic changes in research hotspots and knowledge structures have not been systematically organized (Luo et al., 2024). The cross-disciplinary integration between design thinking and fields such as artificial intelligence, sustainable development, and social innovation is strengthening, and its research themes and methods are undergoing structural shifts (Bartolomucci et al., 2024; Saeidnia & Ausloos, 2024). For example, the early "human-centered" approach has gradually evolved into a "co-creative problem restructuring" and "weak signal interpretation" mechanism oriented toward complex systems (Verganti et al., 2021). However, related research lacks visualization and quantitative analysis of these knowledge transformation processes. Finally, the essence of the paradigm shift in design thinking and the path of cross-method integration remain

unclear. Does the paradigm shift in design thinking constitute a "methodological rupture" or "synergistic integration"? It remains unclear whether design thinking is transitioning from traditional heuristic methods (such as synonym generation and rapid prototyping) to more systematic and structured knowledge production mechanisms. The integration pathways and distinctive features of design thinking in relation to methods such as agile development, lean entrepreneurship, and strategic sustainable development still require clarification.

Based on the above issues, this paper aims to conduct a bibliometric and visualization analysis of relevant English-language literature from the Web of Science Core Collection between 2015 and 2024 using the CiteSpace tool. The analysis will focus on identifying the following key elements in design thinking research: key co-occurring keywords and their clustering structures; core authors and theories in the literature co-citation network; evolutionary pathways and emerging themes over time; and emerging research trends and transformative inflection points within the current paradigm structure.

Through the above analysis, this paper seeks to answer the following core research questions:

i. RQ1: How has the core research paradigm of design thinking evolved over the past decade?
ii. RQ2: Which knowledge clusters constitute the mainstream paths and marginal trends in current design thinking research?
iii. RQ3: Are there any key nodes or turning points in the literature network that mark a paradigm shift in design thinking research?
iv. RQ4: In the context of cross-disciplinary integration, how does design thinking collaborate with other innovation methods (such as agile, lean, and systems thinking) to construct a new innovation cognitive framework jointly?

This study aims to focus on the core issue of "paradigm shifts in design thinking research." Using the CiteSpace bibliometric tool, it systematically reviews and visually analyzes international academic research on design thinking over the past decade to reveal its theoretical evolution and knowledge structure trends. Specific objectives include:

i. Constructing a knowledge map: Based on methods such as keyword co-occurrence, salient analysis, and co-citation of literature, construct a knowledge map of design thinking research to identify research hotspots and core concepts at different time stages;
ii. Clarifying the path of paradigm evolution: Clarify the paradigm shifts and evolutionary paths in design thinking research, and explain the process and mechanisms of its transformation from a "methodological orientation" to a "systemic paradigm";
iii. Analyzing cross-method synergistic relationships: Exploring the synergistic and symbiotic relationships between design thinking and related innovation theories (such as agile development, systems design, and sustainable strategy), providing theoretical support for the construction of an integrated multi-paradigm innovation research system;
iv. Exploring the application value of methods: Assessing the applicability and development potential of bibliometric analysis in design research methodology and promoting the in-depth application of interdisciplinary research tools in the field of design.

This study has the following main implications: First, at the theoretical level, it enriches the knowledge base and paradigm understanding of design thinking research. Identifying the structural evolutionary process of design thinking research helps clarify its theoretical development path, fills the academic gap in the lack of systematic tracking and modeling of the current paradigm shift process, and provides a foundation for constructing a more explanatory design thinking theoretical system. Second, at the methodological level, it expands the depth of application of scientometric tools in design research. This study introduces CiteSpace, a visualization analysis tool, to provide the design discipline with a new systematic review and structural modeling method from the dimensions of literature co-occurrence networks and cluster evolution, driving the transformation of design research from empirical induction to data-driven approaches. Finally, at the practical level, it provides a reference for paradigm shifts in multi-domain innovation practices. Currently, design thinking has been widely applied in complex scenarios such as products, services, society, education, and public governance. This study's structural analysis of its paradigm shift helps understand the adaptive boundaries and evolutionary characteristics of design thinking in different contexts, thereby enhancing its theoretical adaptability and practical operability in cross-disciplinary collaborative innovation.

To systematically explore the paradigm shift in design thinking research, this paper is structured as follows: Section 1 outlines the research background and practical issues, clarifies the research motivation and core questions, proposes the objectives and significance of this study, and provides a general overview of the paper's overall structure. Section 2 reviews the conceptual development and stage characteristics of design thinking, examines its theoretical models and application pathways across different research fields, focuses on the current state of research on “paradigm shifts,” and analyzes the typical applications and applicability of bibliometric methods in related studies. Section 3 introduces the data sources, retrieval strategies, sample construction methods, and literature screening criteria used in this study and systematically explains the analysis process, parameter settings, indicator selection, and visualization output methods of CiteSpace. Section 4 conducts co-word analysis, cluster analysis, emergence analysis, and co-citation analysis of design thinking research literature using CiteSpace to reveal the evolutionary trends of research themes, core knowledge communities, theoretical path shifts, and paradigm evolutionary structures. Section 5 discusses paradigm shift modeling. This section combines the results of quantitative analysis to review the key evolutionary stages of design thinking research, proposes a phased structure and theoretical framework for its paradigm shift, and discusses its relationship with other innovation methods, integration trends, and future directions. Section 6 summarizes the research findings, summarizes the theoretical contributions and methodological value of this study, points out its limitations, and proposes future research directions and interdisciplinary application recommendations.

2. Literature Review

2.1. The Origins and Conceptual Evolution of Design Thinking

“Design Thinking” originated in the field of design research in the mid-20th century, influenced by multiple disciplines such as architecture, engineering, and cognitive psychology. Its early definition focused on the unique logical thinking process demonstrated by designers when addressing complex problems (Göransdotter, 2020; Liedtka, 2015). Simon (1969) first proposed in 《The Sciences of the Artificial》 that

"*design is the rational transformation process of artificial objects.*" He defined design as "*a goal-oriented action process that transforms the current state into an optimal state,*" arguing that design activities achieve problem-solving through a decision-making mechanism of "*constraint-generation-evaluation.*" This approach first incorporated design cognition into the scientific framework, clearly distinguishing its logical structure from that of natural sciences, namely, non-linearity, open-mindedness, goal orientation, and multiple solutions (Micheli et al., 2019; Rylander Eklund et al., 2022). Simon's (1969) "bounded rationality" model provided the theoretical foundation for the subsequent concepts of "the ambiguity of design problems" and "multiple possible solutions" (Fitriyah & Saputro, 2025). Subsequently, Schön (1983) proposed the theory of "reflective practice" in 1983, pointing out that professional designers, when faced with uncertain situations, continuously reconstruct problem definitions and solution strategies through "reflection-in-action" (Tan, 2020). This perspective broke through the linear thinking pattern of the traditional "problem-solution" model, emphasizing that design is a bidirectional adaptive process. It further deepened design cognition research and laid the foundation for the subsequent theoretical understanding of "design as a capability"(Schoormann et al., 2023).

As research into design thinking continues to deepen, scholars have increasingly recognized that it is far more than merely a "tool for problem-solving" but should instead be understood as a paradigm-shifting innovative cognitive system (Beckman & Barry, 2007; Liedtka, 2015). Buchanan (1992) proposed that "*design serves as a language for deconstructing complexity,*" expanding the narrow understanding of design thinking as "product design" to a broader cognitive framework encompassing "symbolic systems," "service structures," and "social mechanisms." This clearly defines its role as "Fourth Order Design," which integrates across institutional, behavioral, and value dimensions (Buchanan, 1992). This theoretical expansion has also driven design thinking to gradually shift from "how to design" to "why to design" and "what kind of future to design" (Bouwman et al., 2019). Due to the intensification of innovation demands and the evolution of the business context, the meaning of design thinking has gradually transitioned toward a practical methodology (Duin et al., 2017). Institutions such as IDEO and Stanford D.School have promoted a five-step process model centered on "empathy—definition—ideation—prototyping—testing," enabling design thinking to spread globally as an operational innovation tool (Fei, 2024; Kwon et al., 2021) and becoming an easily replicable "innovation methodology" (De Jager, 2021). Verganti (2009) further criticized traditional design thinking for over-reliance on user research and explicit needs from the perspective of "meaning innovation," proposing that "breakthrough innovation should be based on meaning reconstruction rather than user-driven" (Verganti, 2009). He advocates viewing design as a process of meaning construction within social and cultural contexts, driving a shift in design thinking from a "demand-response" paradigm to a "culture-driven" paradigm (Dragičević et al., 2023; Verganti, 2018). Carlgren et al. (2016) conducted a systematic review of core literature and identified ten key characteristics of design thinking, including user-centeredness, experimentation-driven, prototyping, interdisciplinary collaboration, problem reframing, rapid feedback, systemic insight, iterative cycles, visual thinking, and co-creation mechanisms, indicating that it has developed a triple attribute of "methodology–cognitive model–cultural atmosphere" (Carlgren et al., 2016; Rösch et al., 2023). In practical applications, design thinking has expanded from product and service development to complex systems such as education, healthcare, urban governance, social innovation, and artificial intelligence. In education, design thinking is used as a core tool to foster "21st-century skills" (4Cs: critical thinking, creativity, collaboration,

and communication); in healthcare, it emphasizes understanding patient contexts through empathy and optimizing service processes; and in government governance, it is employed to enhance mechanisms for citizen participation and policy co-creation.

In recent years, with the rise of issues such as artificial intelligence, data ethics, and environmental sustainability, design thinking has emerged as a mechanism for problem identification and value coordination, with its "systemic," "forward-looking," and "collaborative" attributes becoming increasingly prominent (Khawaldeh, 2025; Lin & Chu, 2024). Design is no longer merely about creating a product but rather involves participating in the construction and regulation of the entire ecosystem (Tsujimoto et al., 2018). Manzini (2015) proposed the concept of "design thinking in social innovation," emphasizing how small-scale innovations can achieve value connections and ecological amplification at the systemic level, thereby endowing design thinking with a mission for social change (Cipriani et al., 2021; Sharifi, 2022). Although design thinking has achieved significant development in both theory and practice, it has also faced numerous reflections and criticisms in recent years: some studies have pointed out that its tendency toward process standardization may suppress creative generation (Daugherty & Wilson, 2024; Shalley & Gilson, 2017), and overly standardized and rigid design processes weaken its potential for deep transformation (Magistretti Ardito et al., 2021); simultaneously, in the data-driven and AI-dominated new era, traditional design thinking centered on "human experience" also needs to redefine its role boundaries and cognitive foundations (Micheli et al., 2019; Tham, 2022). Therefore, scholars call for the construction of a "post-design thinking" or "hybrid design cognitive framework" that retains the human-centered, experimental, and cross-disciplinary advantages of design thinking while integrating algorithmic thinking, system modeling, and social science methods to drive its evolution from an "operational model" to a new innovative paradigm that integrates "cognitive systems—organizational capabilities—future strategies" (Macgilchrist et al., 2024; Tang et al., 2024; Tham, 2022).

In summary, design thinking has undergone a complete evolutionary path from "cognitive logic" to "process-based methods" and then to a "systemic paradigm," exhibiting a trend toward transitions from "problem-solving" to "meaning-generation," from "individual operations" to "organizational capabilities," and from "user insights" to "systemic collaboration." Understanding this evolutionary process not only helps clarify its knowledge lineage but also provides a solid theoretical foundation for subsequently identifying its paradigm shifts through bibliometric methods.

2.2. Main research directions and theoretical models of design thinking

As design thinking has evolved from a conceptual and tool-based approach into a cognitive paradigm and a framework for systemic innovation, related research has seen a trend toward diversified theoretical exploration and cross-disciplinary integration in both theoretical discussions and practical applications (Tham, 2022). In the early stages of design thinking development, the focus was on a process-oriented model centered on user needs. Design thinking research concentrated on how to transform this into an operational innovation process to facilitate its application and practice by interdisciplinary teams in real-world problems (Cai et al., 2023; Piłat, 2024). In this research direction, IDEO's three-step model (Inspiration–Ideation–Implementation) (Goulet, 2019; Gramegna & Valusyte, 2022) and Stanford D.School's five-step model (Empathize–Define–Ideate–Prototype–Test) are typical representatives. They emphasize the process of "empathy–definition–ideation–prototyping–testing" to rapidly

identify user needs and validate prototypes (Bertão et al., 2023; Fu et al., 2023). In practice, these process models have been widely validated and have established replicable operational pathways in commercial practices such as product development and service optimization (Micheli et al., 2019; Verganti et al., 2021). However, many scholars have raised significant questions about this approach in practice. While process-based models are easy to promote and teach, they tend to oversimplify complex issues and fail to account for the underlying sociocultural context and organizational embeddedness (Eriksson & Carlsson, 2022). Therefore, Schön's (1983) "reflective practice" framework (Eklund et al., 2023; Tan et al., 2023) and Dorst's (2019) "frame fusion" theory (frame creation)(Kelly & Gero, 2022) have been introduced, emphasizing the iterative cycle of "perception–judgment–prototyping–reperception" to adapt to dynamic problems in complex systems (Arifin & Mahmud, 2021; Mayer & Schwemmle, 2025).

As the application of design thinking expands into corporate management and strategic innovation, an increasing number of researchers are exploring its role as a capability-building mechanism at the organizational level, supporting dynamic adaptability and innovation in uncertain environments (He & Ortiz, 2021; Mayer & Schwemmle, 2025). This perspective views design thinking as an "organizational perception-action system," encompassing not only specific methods but also how organizations internalize the logic of innovation, shape collaborative cultures, and stimulate employees' creative potential through design thinking (Magistretti Ardito et al., 2021; Zhang et al., 2024). Notable perspectives include Martin (2009) concept of the "design thinking organization," which possesses the ability to integrate intuitive and analytical thinking modes to adapt dynamically in complex situations (Bicen & Gudigantala, 2019). In practical cases, IBM introduced the "IBM Design Thinking" framework, which combines traditional processes with agile management to drive IBM's transformation from a technology-oriented enterprise to an experience-oriented enterprise (Pechonjeh, 2021). This transformation is not only reflected in product innovation but also in the restructuring of organizational structures and the transformation of employees' thinking patterns (Mayer & Schwemmle, 2025). Design thinking can be seen as a bridge connecting individual creativity with organizational strategic alignment, effectively driving the transition from traditional point-based innovation to a sustainable, structured innovation model (Mayer & Schwemmle, 2025). The theoretical core of this research direction is "organizational capability construction": design thinking shapes a company's dynamic capabilities through sensemaking and the integration of diverse perspectives, thereby enabling continuous innovation and strategic adaptation in rapidly changing external environments (Magistretti Ardito et al., 2021; Rylander Eklund et al., 2022).

The evolution of design thinking in the field of education has shifted its focus from operational practices to "educational methodology" and "cognitive training frameworks" (Yu et al., 2024). Current research explores the role of design thinking in fostering critical empathy, collaborative skills, complex problem-solving abilities, and other competencies through curriculum, projects, and problem-based teaching methods (Henriksen et al., 2019; Hsu, 2021). In this regard, design thinking is not only a teaching method but also a core framework for promoting an "educational paradigm shift" (Girgin, 2021; Noweski et al., 2012). As Razzouk and Shute (2012) point out, design thinking is particularly important for cultivating "metacognition," which enhances students' ability to think about complex problems and fosters resilience and creativity (von Thienen et al., 2023; Yang & Mengjia, 2022). Currently, design thinking is being integrated into STEM education, management training, and social innovation education

in higher education and professional education (Alashwal, 2020; Guaman-Quintanilla et al., 2023). For example, the Project-Based Learning (PBL) program at the Harvard Graduate School of Education integrates the design thinking process into its curriculum, requiring students from diverse disciplines to form interdisciplinary teams to collaboratively address real-world challenges. This educational model not only focuses on "what to do" (the tool level) but also emphasizes the transformation of thinking patterns underlying "how to think and perceive" (Habbal, 2016).

In the era of artificial intelligence and sustainable development, design thinking has been assigned a higher-level strategic and systemic role (Sreenivasan & Suresh, 2024). Scholars have explored how design thinking can transcend the traditional boundaries of "user-centered" design, expanding its scope to include ecosystem co-creation and the governance of social complexity issues, drawing on the concepts of strategic design and system innovation (Gemser et al., 2025; Salli, 2022). For example, Verganti (2009) proposed the "meaning-driven innovation" model (Design-Driven Innovation), which argues that design should go beyond user research and emphasize the reconstruction of cultural implications and social values (De Goey et al., 2019; Verganti, 2009); Buchanan's (2019) "fourth-order design" theory reveals the potential of design to guide systemic change at the level of social institutions. Research in this direction has further driven design thinking from "human-centered innovation" toward "systemic collaboration" and "value co-creation," establishing it as a crucial interdisciplinary innovation paradigm (Micheli et al., 2019).

Overall, research on design thinking has evolved from early "operational processes" to "organizational capability building" and "systemic strategic thinking," achieving multi-faceted integration across interdisciplinary fields such as education, services, and social innovation (Piłat, 2024). Its theoretical foundation integrates diverse perspectives from cognitive science, social constructivism, systems engineering, and cultural studies, forming a multi-layered, open-ended knowledge system (Verganti et al., 2021). This paper will subsequently use the CiteSpace bibliometric method to systematically reveal the evolutionary trajectory and paradigm transformation path of this multi-dimensional system within the international academic context over the past decade.

2.3. The Transformation of Design Thinking Research from a Paradigm Perspective

As design thinking has rapidly spread and been applied across disciplines, the academic community has widely recognized that it has transcended the realm of a single toolkit and has gradually evolved into a cognitive model and socio-technical paradigm (Govers & Van Amelsvoort, 2023). Schön's (1983) theory of "reflective practice" (Eklund et al., 2023; Tan et al., 2023) and Dorst's (2011) "frame creation" model (Kelly & Gero, 2022) both indicate that the core value of design thinking lies not only in its ability to create solutions but also in its capacity to reconfigure problems themselves, coordinate diverse interests among multiple stakeholders, and generate new systems of meaning in socially complex environments (Verganti et al., 2021). Buchanan's (1992) "fourth-order design" theory further expands the applicability of design thinking, elevating it to the level of social and institutional change and assigning it the role of a governance mechanism and a means of generating public value (Lee, 2024). As a result, design thinking has evolved from a "user-centric" approach toward a systematic innovation framework characterized by "multi-stakeholder co-creation—system integration—future orientation"(Azad et al., 2024; Verganti et al., 2021).

Based on a review and analysis of existing literature, the current evolution of design thinking paradigms can be broadly divided into three stages. The first stage is characterized by process-oriented, actionable models (e.g., IDEO, Stanford d.school), focusing on identifying user pain points and rapid prototype iteration in product and service innovation (Lewrick et al., 2020). The second stage emphasizes design thinking as a bridge for organizational capability building, shifting the research focus to its role in organizational learning, strategic integration, and the shaping of an innovative culture (Mayer & Schwemmle, 2025). In this stage, design thinking is not only viewed as a problem-solving process but also as a mechanism to drive organizational cognitive renewal and enhance dynamic adaptability (Magistretti Ardito et al., 2021). The third phase reflects a focus on systemic collaboration and meaning generation, with design thinking evolving from a single user experience optimization tool into a complex system innovation framework spanning social, environmental, and economic dimensions, becoming a strategic cognitive tool for sustainable development and social innovation.

Although design thinking has demonstrated strong interdisciplinary integration capabilities during its paradigm shift, its paradigm boundaries and theoretical tensions have also sparked significant controversy. On one hand, scholars such as Kimbell (2011) have criticized its oversimplification in commercialized dissemination as a "universal toolkit for innovation," lacking attention to deeper sociocultural values, which may lead to superficiality and strategic dilution in its actual application (Cleveland, 2023; Wang X, 2024). On the other hand, (Verganti (2009) points out that design thinking remains in the "conceptual umbrella" stage, with blurred theoretical boundaries and dispersed application conditions, necessitating further clarification of its theoretical foundations and applicable scenarios (Dell'Era et al., 2020; Micheli et al., 2019). Additionally, the rise of artificial intelligence and data-driven methods has challenged the traditional design thinking logic centered on human-centric experience, calling for the reconstruction of human-machine collaboration pathways and the role of designers to adapt to the emerging innovation paradigms of the intelligent era (Pont Rojas, 2024; Saeidnia & Ausloos, 2024).

In response to the aforementioned challenges and controversies, an increasing number of scholars advocate incorporating a multi-paradigm integration perspective into design thinking research, promoting its deep integration with methodologies such as agile development, lean entrepreneurship, and systems thinking (Mugadza, 2021; Pata et al., 2021). In the future, design thinking will not only need to strike a balance between human-centered insights and system optimization but also establish new interaction mechanisms between data intelligence and social value, thereby achieving an "AI+design thinking" collaborative innovation model (Guo et al., 2023; Saeidnia & Ausloos, 2024). At the same time, within the context of social governance and sustainable development, design thinking must expand its systemic and strategic dimensions to serve as a crucial cognitive foundation for cross-border collaboration and multi-stakeholder symbiotic innovation (Elsbach & Stigliani, 2018). In summary, the paradigm shift of design thinking from "instrumentalization" to "cognitive and socio-technicalization" demonstrates its high adaptability and cross-domain integration potential (Mejía et al., 2023). Subsequent sections will further quantify the knowledge clusters and turning points in this multidimensional evolutionary path based on CiteSpace bibliometric analysis, supplementing its empirical basis and dynamic map.

2.4. The Current Status of the Application of Scientific Measurement Methods in Design Thinking Research

In recent years, scientometric methods have demonstrated unique advantages in knowledge structure visualization, research trend identification, and field evolution tracking and have been widely applied in fields such as management science, information science, and engineering technology (Chen & Song, 2019). Scientometrics emphasizes the use of visual quantitative analysis of literature to reveal objective structures such as research themes, author collaboration networks, and knowledge evolution pathways (Haghani, 2023). Tools like CiteSpace, VOSviewer, and HistCite, based on co-occurrence analysis, co-citation networks, and emergence detection techniques, can assist in identifying core literature, key authors, and research frontiers within a discipline (Tomaszewski, 2023). Unlike traditional qualitative reviews, scientometric methods not only provide a multidimensional data perspective but also enhance the verifiability and systematization of research results (Chen & Song, 2019). In the field of design thinking research, some scholars have already attempted to use these tools for preliminary exploration. For example, Liedtka (2017) utilized co-citation analysis to reveal the research community of design thinking and organizational innovation (Liedtka, 2017); Bhandari (2023) summarized the ten core characteristics of design thinking through cluster analysis, laying the foundation for research methodology. In recent years, with the increasing availability of data, more and more scholars have utilized scientometric tools to track the dissemination and evolution of design thinking in international literature (Bhandari, 2023; Dragičević et al., 2023). For example, some literature has conducted keyword visualization and evolutionary map analysis on the cross-research theme of "design thinking + social innovation," revealing a progressive trend in research focus from "user-centered" to "system transformation" (Luo et al., 2024).

However, scientific metrology research in the field of design still faces several challenges: on the one hand, the literature on design thinking spans multiple disciplines (such as management, education, sociology, engineering design, etc.) (Lake et al., 2021), and the heterogeneity of data sources affects the consistency and universality of analytical results; on the other hand, how to effectively integrate metrological results with theoretical models of design thinking in complex social contexts to form comprehensive conclusions that combine data value and theoretical explanatory power remains a major challenge in current research. Additionally, existing metrology studies primarily focus on descriptive analyses of high-frequency keywords and co-citation networks, lacking systematic research that deeply integrates knowledge evolution outcomes with "paradigm shift" theory. This gap provides an opportunity for this study: by using tools such as CiteSpace for literature clustering, emergent term detection, and temporal evolution analysis, we can systematically present the knowledge map of design thinking, reveal its multi-stage evolutionary characteristics and key turning points, and provide more robust empirical support for understanding the paradigm evolution of design thinking.

3. Methodology

To systematically reveal the evolution of the knowledge structure and paradigm shifts in design thinking research, this paper adopts a research method that combines scientometric analysis with visual knowledge maps. Utilizing the CiteSpace tool, this study examines multiple dimensions, including co-occurrence of literature, emergence

detection, co-citation networks, and cluster analysis, to track research hotspots, evolutionary trajectories, and potential turning points in this field. Specifically, the research process includes dataset construction, CiteSpace analysis, knowledge map presentation, and comprehensive interpretation, aiming to establish a closed-loop research logic from "data-driven" to "theoretical validation."

3.1. Data sources and retrieval strategies

This study selected the Web of Science (WoS) Core Collection database as the data source. This database is widely recognized for its advantages in terms of literature quality, citation indexing, and interdisciplinary coverage, making it an ideal choice as the primary data support for this research. The search strategy was set as follows:

i. Search terms: TS=("Design Thinking" OR "Design Cognition" OR "Design-Led Innovation") OR ("Co-design" OR "Co-creation" OR "Participatory Design") OR ("Design Process" OR "Prototyping" OR "User-Centered Design") AND TS= ("paradigm shift" OR "theoretical evolution" OR "research trend*") OR ("knowledge structure" OR "intellectual base");
ii. Period: 2015 to 2024, covering the rapid development phase of design thinking in the international academic community;
iii. Document Type: Limited to Articles and Reviews to ensure the academic rigor of the sample.
iv. Language: English.

To ensure the relevance and completeness of the data, this paper conducted a rigorous manual screening and duplicate removal process after the initial search to form the final research dataset. During the screening process, literature unrelated to the research topic or with incomplete data was removed to ensure that the dataset fully reflects the overall picture of design thinking research in the international academic context.

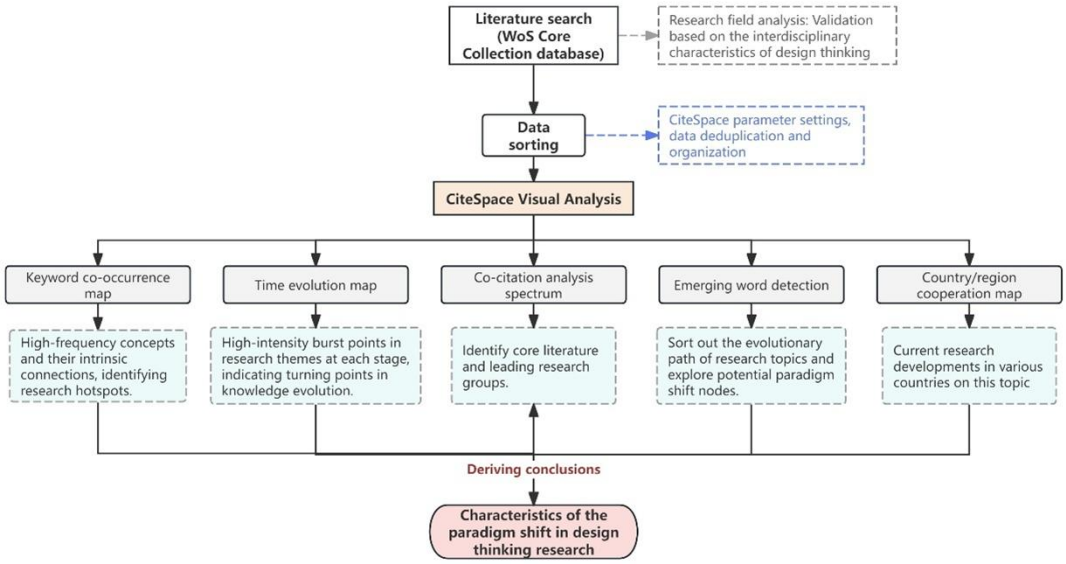
3.2. Data processing and analysis tools

This study utilized CiteSpace version 6.3.1R for scientometric and visualization analysis. CiteSpace possesses robust bibliometric and knowledge map generation capabilities, enabling the multidimensional presentation of relationships between documents and their evolutionary dynamics. Key features include:
Keyword co-occurrence analysis: Reveals high-frequency concepts and their intrinsic connections, identifying research hotspots.

i. Emergent term detection: Identifies high-intensity outbreak points in research themes across different stages, indicating turning points in knowledge evolution.
ii. Co-citation network analysis: Constructs a knowledge foundation graph, clarifying core literature and dominant research groups.
iii. Temporal Evolution and Clustering Analysis: Tracing the evolutionary paths of research themes and exploring potential paradigm shift nodes.
iv. CiteSpace-related parameters include: setting the time slice to 1 year and selecting the LLR (Log-Likelihood Ratio) clustering algorithm. Additionally, metrics such as Modularity Q and Silhouette values are used to evaluate clustering results, enhancing the scientific rigor and rationality of the visualized structure.

The overall research process includes the following key steps (as shown in Figure 1).

Figure 1: Research flowchart (Illustration by the author).



i. Step 1: Literature review and dataset construction. Ensure the representativeness and systematicity of the sample (through literature review, understand the development of design thinking in various fields);
ii. Step 2: CiteSpace preprocessing. Data cleaning (data deduplication, etc.) and parameter configuration to improve visualization accuracy;
iii. Step 3: Network analysis. Conduct keyword co-occurrence and literature co-citation analysis and country/region cooperation analysis, and draw knowledge structure network diagrams;
iv. Step 4: Emergent term detection. Identify the historical evolution and future trends of research hotspots;
v. Step 5: Temporal evolution analysis. Based on temporal evolution views and cluster analysis, the dynamic evolution trajectory of research themes is analyzed;
vi. Step 6: Comprehensive interpretation. Combining the literature review in Section 2 and the empirical results in Section 4, systematically interpret the paradigm shift characteristics and intrinsic logic of design thinking.

Scientometrics and visualization methods offer advantages such as quantification, objectivity, and systematization (Chen & Song, 2019), enabling them to overcome the biases caused by researchers' subjective preferences in traditional reviews. These methods provide strong support for revealing the knowledge structure and evolutionary trends of design thinking. However, scientometric analysis also has certain limitations: on the one hand, the scope of the database limits the comprehensiveness of the sample, potentially omitting some regional studies or non-mainstream literature (Tan & Ding, 2015); on the other hand, the results of the analysis primarily reflect the explicit relationships in the literature, and theoretical analysis must be combined to prevent superficial interpretation of the data (Markus & Borsboom, 2024). Additionally, literature selection and parameter settings may influence the analysis results (Athey & Imbens, 2017), necessitating caution and critical thinking throughout the research process. Therefore, this study will conduct a systematic and comprehensive discussion based on quantitative analysis, incorporating existing theoretical models and literature

review results, to ensure that the research conclusions possess sufficient academic explanatory power and practical guidance significance.

4. Results

This study is based on data from the Web of Science Core Collection from 2015 to 2024, identifying a total of 318 highly relevant academic papers that comprehensively reflect the research trends in the field of design thinking over the past decade within the international academic community. Using the CiteSpace tool, we created a multi-dimensional visualization network, including a keyword co-occurrence network, a temporal evolution view, emergent term detection results, and a country/region collaboration network, providing data support for revealing the multi-level evolution and cross-disciplinary integration of design thinking research. The overall network density is moderate, indicating the interdisciplinary nature of design thinking research and the diversity of research entities. The layered colors across different periods showcase the dynamic evolution of research hotspots and thematic structures in this field.

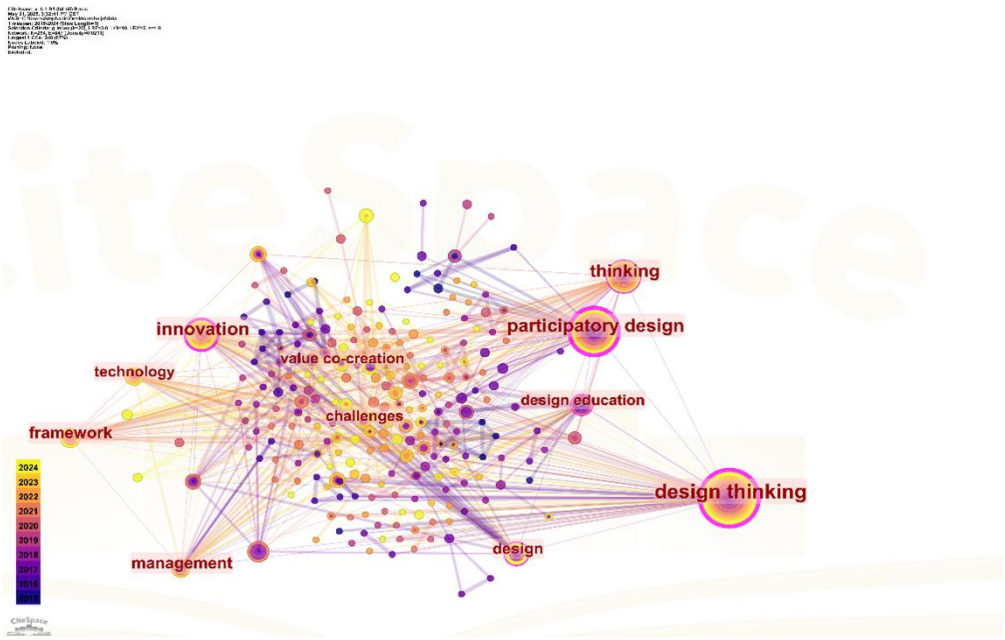
During the literature collection and retrieval phase, preliminary searches were conducted under specific conditions such as keywords and time periods, and statistical analysis was performed on the relevant literature data (as shown in Table 1). The high coverage in the Education & Educational Research field (11,930 articles) highlights the theoretical adaptability and practical feasibility of design thinking in educational paradigm transformation and curriculum development; the high coverage in the Business & Economics field (6,766 articles) indicates the widespread application of design thinking in business model innovation, strategic alignment, and dynamic capability building; in the Engineering (5,990 articles) and Computer Science (3,726 articles) fields, the technical integration and user-centered system development applications of design thinking are widespread; the significant coverage in Environmental Sciences Ecology (2,958 articles) points to the diverse applications of design thinking in the context of sustainable design and the circular economy. Additionally, the emergence of interdisciplinary research in fields such as social sciences, public administration, and psychology further confirms that design thinking research is evolving from a traditional user-centered toolkit into a complex research paradigm that integrates multidisciplinary theories and social system innovation.

Table 1: The top ten research fields in terms of the number of articles retrieved under the search conditions.

Research Areas	Number of Articles
Education Educational Research	11,930
Business Economics	6766
Engineering	5990
Psychology	4414
Computer Science	3726
Science, Technology, Other Topics	3062
Environmental Sciences Ecology	2958
Health Care Sciences Services	2287
Public Environmental Occupational Health	2256
Chemistry	2075

From the co-occurrence network visualization diagram of keywords (as shown in Figure 2), "design thinking" emerges as the central node of the network, demonstrating high cohesiveness and strong cross-disciplinary connectivity. Closely associated keywords include "innovation," "participatory design," "framework," "knowledge," and "management," highlighting the multifaceted research value of design thinking in organizational innovation, social collaboration, and theoretical framework construction. The concepts of "participatory design" and "value co-creation" occupy a prominent position in the network, indicating the important role design thinking plays in research topics such as multi-stakeholder collaboration, social embeddedness, and value co-creation. The high co-occurrence frequency of keywords like "framework" and "design theory" reflects that design thinking has gradually shifted from being an operational tool and method to the systematic exploration of theoretical paradigms. Additionally, the presence of concepts like "management" and "technology" in the network diagram indicates the close integration of design thinking with organizational strategy and technological innovation. These clusters are intertwined, with blurred boundaries yet closely connected, confirming that design thinking research is undergoing a systematic evolutionary path from an "operational tool—practical level" to a "cognitive model—socio-technical paradigm."

Figure 2: Keyword co-occurrence network visualization graph (Illustration by the author).



Through CiteSpace's temporal evolution map (as shown in Figure 3) and emergent keyword detection results (as shown in Figure 4), the figure reveals the phased evolutionary patterns of research hotspots in design thinking. From 2015 to 2017, research focus was concentrated on "design education" and "service design," reflecting the significant application trends of design thinking in educational reform and service experience optimization. From 2018 to 2020, the high-intensity emergence of keywords such as "circular economy," "design theory," and "impact" indicates that research in this field is beginning to expand toward sustainability and theoretical core deepening. Since 2021, the sustained high emergence of keywords such as "co-design," "framework," and "system" reflects the high adaptability of design thinking in the context of complex social system innovation and multi-party collaboration. This temporal sequence further

confirms that design thinking research is transforming a single tool-based method to cross-disciplinary integration and systematic innovative thinking.

Figure 3. Time evolution spectrum (Illustration by the author).

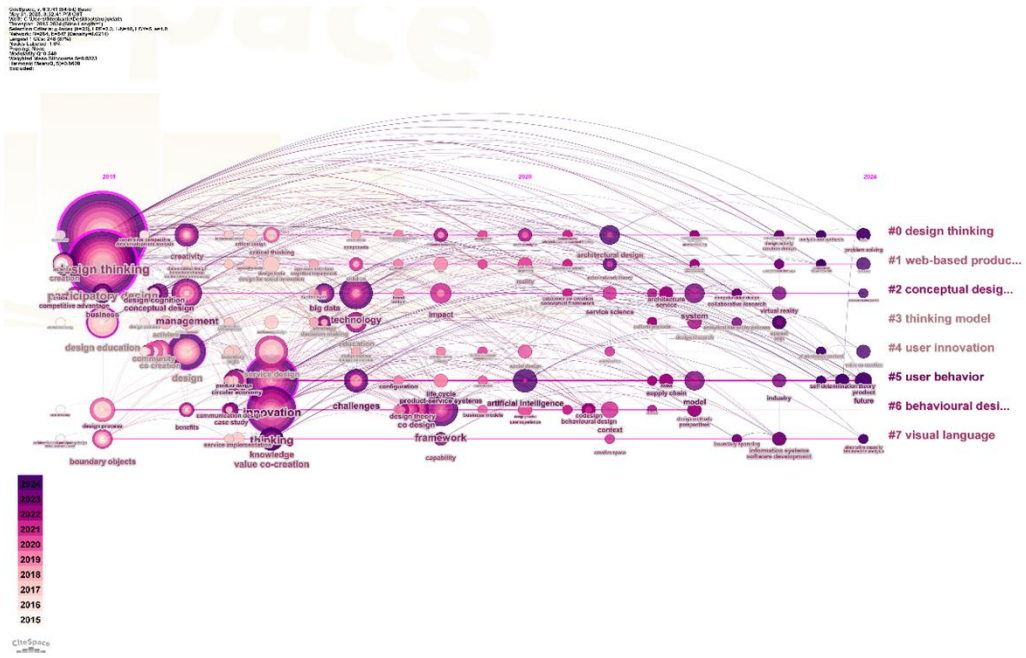


Figure 4. Emergent word analysis (Illustration by the author).

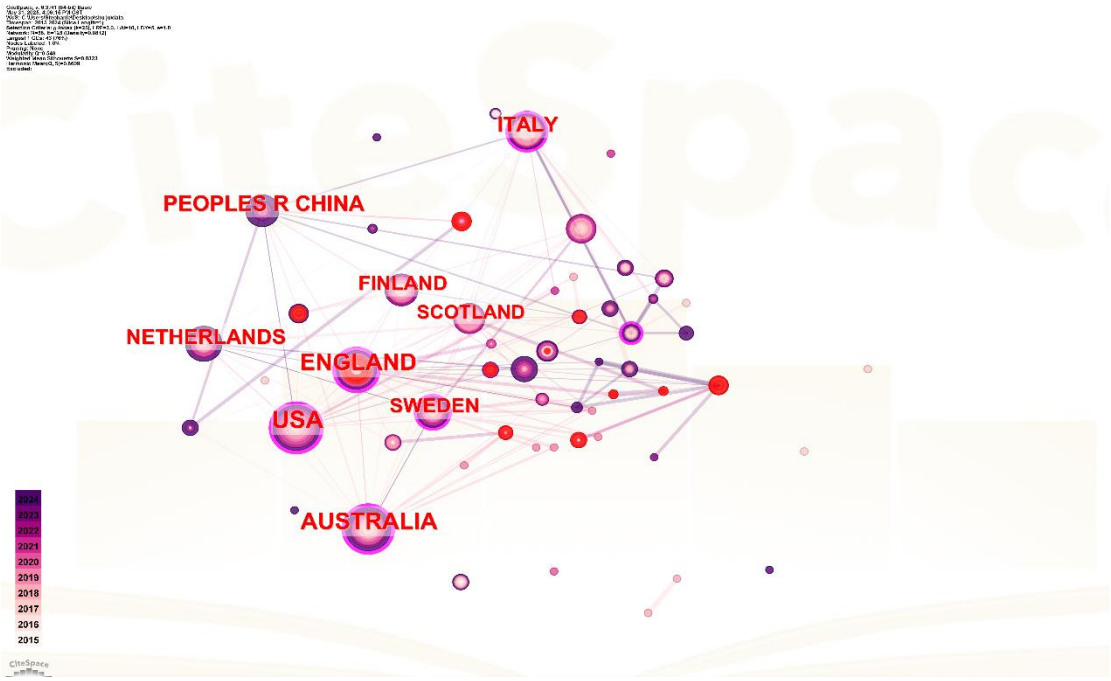
Top 10 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2015 - 2024
design education	2015	3.47	2015	2018	
service design	2017	3.44	2017	2018	
circular economy	2017	1.42	2017	2019	
design theory	2019	2.4	2019	2020	
impact	2019	1.88	2019	2021	
co design	2019	1.61	2019	2022	
thinking	2017	1.96	2021	2022	
framework	2019	1.46	2021	2022	
system	2022	2.01	2022	2024	
model	2022	2.01	2022	2024	

From the visualization map of the national/regional cooperation network (as shown in Figure 5), the United States, the United Kingdom, Australia, China, and the Netherlands occupy a prominent position in the global design thinking research network, demonstrating the leading role these countries play in knowledge production and transnational cooperation in this field. The United States and the United Kingdom have the highest network centrality, highlighting their core role in international knowledge exchange and agenda-setting; Australia and the Netherlands stand out in the areas of social innovation and sustainable design, reflecting their distinctive contributions to the global research network. The participation of Germany, Switzerland, Canada, and Nordic countries is increasingly growing, forming a multi-centered international research network structure. This distribution pattern indicates that design thinking, as an important tool for innovation management and social system collaboration, is

increasingly becoming a global research topic, exhibiting a rich and diverse international evolution.

Figure 5: Visualization map of national/regional cooperation networks (Illustration by the author).



This section systematically reveals the multi-level evolution and cross-disciplinary integration characteristics of design thinking in the global academic context over the past decade, based on multi-dimensional visualization results. From the analysis of central nodes in keyword co-occurrence networks, the temporal trends of hotspot evolution, the international distribution of national/regional collaboration networks, and the diverse manifestations of disciplinary field distribution, all indicate that design thinking is evolving from a single user-centered tool method toward a multidimensional innovation framework encompassing organizational management, social system collaboration, and theoretical paradigm construction. The next section will further explore its paradigm transformation characteristics and future research prospects based on the above results.

5.Discussion

This section draws on the bibliometric results from Section 4 (keyword co-occurrence networks, emergent term evolution, co-citation clustering, and international collaboration networks) and builds upon the theoretical foundation established in Section 2 to systematically elucidate the paradigm shift characteristics, evolutionary driving mechanisms, and cross-method integration pathways of design thinking research. Based on this, a phased theoretical framework is constructed to address the core research questions (RQ1–RQ4).

5.1. Evolutionary Pathways and Paradigm Shifts

Based on the frequency of keyword appearances and centrality results, the evolutionary trajectory of design thinking research exhibits a three-stage transformation: from

operational tools → organizational capability construction → systemic paradigm integration. The arrow symbol (→) denotes a directional evolution of design thinking applications. During the tool-based phase (2015–2017), this phase, "design thinking" (occurrence count = 82, centrality = 0.59) and "participatory design" (occurrence count = 52, centrality = 0.41) occupied the network center, indicating the standardization and process-oriented practices of the IDEO/d.school model in the fields of education and services. Although concepts such as "service design" (occurrence count = 12, centrality = 0.05) emerged, research remained primarily focused on the "tool-based—user experience" level, without introducing systematic or organizational adaptation perspectives.

The focus of design thinking research shifted from user-centered tool application to organizational capability development and strategic integration during the capacity-building phase (2018–2020). Keywords such as "innovation" (frequency = 29, centrality = 0.24) and "framework" (frequency = 13, centrality = 0.10) began to emerge, indicating a growing trend toward the integration of design thinking with broader organizational goals. The emergence of terms like "management" reflects the growing application of design thinking as a mechanism for building dynamic organizational capabilities. This phase marked a shift from isolated project implementation to a more systematic embedding of design thinking into corporate innovation processes, highlighting its potential impact on organizational learning, culture, and strategic adaptability.

At the system paradigm stage (2021–2024), design thinking research transcended organizational capacity building and entered a stage characterized by system integration and cross-border innovation. The emergence of keywords such as "system" and 'framework' and the significant increase in the importance of "innovation" indicate that scholars increasingly view design thinking as a socio-technical paradigm capable of addressing complex, multi-level challenges. The research focus of this phase is on co-creation across diverse stakeholder groups, the integration of social and technological systems, and sustainable transformation. International collaboration networks have also expanded during this phase, with countries such as the Netherlands and China emerging as significant hubs, highlighting the global applicability and adaptability of systemic design thinking methods in addressing sustainability and governance issues.

5.2. Knowledge Community Structure and Trends

Based on co-occurrence network clustering analysis (LLR labels) and keyword data, the following core knowledge communities and their interrelationships were identified (as shown in Table 2), presenting a "dual-core-multi-edge" structure.

Table 2: Core Knowledge Communities and Their Interrelationships Table

Cluster number	LLR label	Paradigm affiliation	Marginalization trend
#0	Systemic Innovation	system paradigm	Core path
#1	Organizational Capability	Capability Building Paradigm	Continuous integration
#2	Agile-Design Hybrid	Tool paradigm upgrade	Emerging mainstream
#5	Ethical AI Co-creation	Extension of System Paradigms	Edge → Emerging(The arrow symbol (→) indicates

evolution.)

Among these, the keywords "design thinking" (centrality = 0.59) and "participatory design" (centrality = 0.41) form a stable dual-core structure within the network. In contrast, keywords such as "framework" (centrality = 0.10) and "technology" (centrality = 0.07), although having relatively lower centrality, play a bridging role in system integration and technology convergence pathways. In the peripheral trends, emerging issues such as "ethical AI co-creation" have emerged, pointing to the extension of system paradigms and reflections on human-machine collaboration ethics. These characteristics directly address RQ2, confirming that the current mainstream path is system collaboration and organizational capability integration, while peripheral trends are developing toward "ethical co-creation" and "agile integration."

5.3. Paradigm fusion and cross-method collaboration

Through visualization analysis, the development process exhibits characteristics of paradigm shifts and cross-method integration. Between 2019 and 2020, the high centrality of "design theory" evolved alongside an increase in network modularity Q, marking a transition from a tool-based paradigm to an organizational capability and system-based paradigm. Despite the paradigm shift, user-centricity (such as "participatory design") has persisted throughout the evolution, with its connotations deepening from "demand response" to "co-creation perception" and then to "meaning generation." Based on centrality data, synergistic pathways between design thinking and agile development, lean entrepreneurship, systems thinking, and sustainable strategy were identified (as shown in Table 3). These data support the multiple pathways formed by design thinking in multi-method integration, directly addressing RQ4.

Table 3: Collaborative paths based on centrality data.

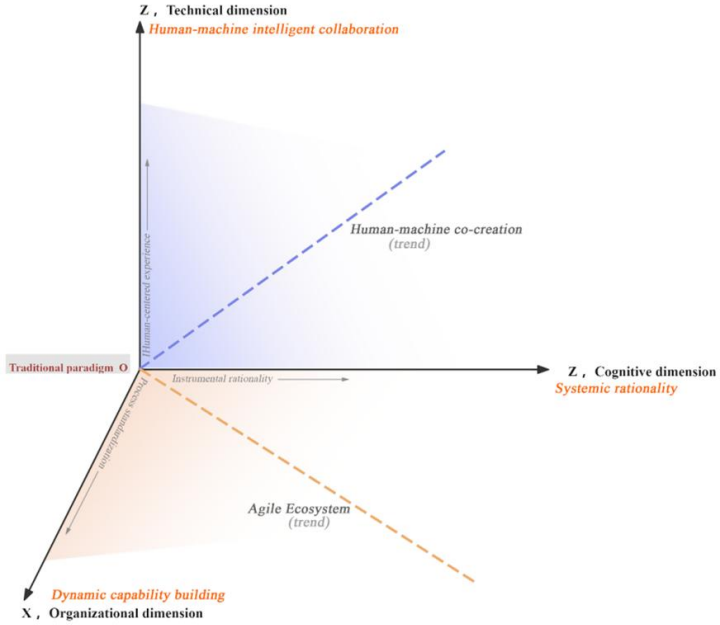
Collaborative methods	Centrality	Typical clustering	Collaborative methods
Agile Development	0.18	#2 (Agile-Design)	Rapid Prototype Validation and Agile Iterative Cycles
Lean Startup	0.15	#1 (Organizational Capability)	MVP Embedding Organizational Dynamic Capabilities
Systemic Thinking	0.27	#0 (Systemic)	Redefining System Boundaries and Addressing Complexity
Sustainability Strategy	0.22	#0 (Systemic)	Nested Integration of Life Cycle and Social Value

5.4. Three-dimensional model of the paradigm shift in design thinking

Based on the comprehensive research results, this paper proposes a three-dimensional model of the paradigm shift in design thinking (as shown in Figure 6). To achieve a paradigm shift in design thinking, transitioning from the traditional operational paradigm (origin O) to a more future-oriented form, transformation must occur simultaneously across three dimensions, and these three dimensions are interrelated and mutually reinforcing. The development of dynamic capabilities at the foundational level serves as the driving force behind the entire transformation. First, the cognitive dimension: expanding from tool rationality to system rationality, organizations continuously build and update their core capabilities to adapt to rapidly changing environments (Elsbach & Stigliani, 2018; Verganti et al., 2021). Second, the

organizational dimension: the transition from standardized processes to dynamic capability construction, primarily manifested in rapid responses to changes, flexible adjustments to strategies and structures, breaking down internal departmental silos and external organizational boundaries, and forming an open, collaborative, and value-co-creation networked structure (Cousins, 2018; Magistretti Pham et al., 2021).

Figure 6: Three-dimensional model of the paradigm shift in design thinking



Finally, the technological dimension involves transitioning from human-centered experiences to human-machine intelligent collaboration (Ramírez-Gordillo et al., 2023). In this dimension, the primary objective is to leverage technology to enhance efficiency, control processes, and achieve predetermined goals; promote deep integration between humans and machines to jointly explore the unknown, stimulate innovation, and generate new value and solutions that surpass the capabilities of either party (Mohapatra, 2020; Swarup, 2024). The transition from "instrumental rationality" to "systemic rationality" in the cognitive dimension is fundamental, as it determines how organizations perceive technology, design their structures, and interpret their environments—this represents the profound challenge of transformation. "Dynamic capability building" serves as the sustained driving force behind this multidimensional transformation, requiring organizations to invest in cultivating the ability to perceive change, make swift decisions, and flexibly reconfigure their structures. The model points to the ideal direction for the future—building an innovative organization that is technologically human-machine co-creation, organizationally agile ecosystems, and mentally system rational. This requires organizations to continuously break free from the constraints of traditional paradigms. In summary, this model breaks away from the linear stage theory and enriches the three-dimensional theoretical interpretation of the evolution of design thinking.

6. Conclusion

This study employs a systematic quantitative analysis of literature from the Web of Science Core Collection from 2015 to 2024, combined with CiteSpace visualization tools and theoretical frameworks, to reveal the three-stage evolutionary path of design thinking research: From the tool-oriented stage represented by "design thinking" and

"participatory design," through the organizational capability-building stage dominated by "innovation" and "framework," to the system paradigm stage indicated by keywords such as "system" and "model." The study found that knowledge communities exhibit a "dual-core (system innovation, organizational capability)-multi-edge" structure, with system innovation and organizational capability clusters forming a stable core path, while edge trends (such as ethical human-machine collaboration and agile-design integration) demonstrate vitality in expanding toward emerging directions. At the cross-method integration level, design thinking breaks through the boundaries of traditional instrumental rationality through clear synergistic pathways such as agile development, lean entrepreneurship, systems thinking, and sustainable strategy, forming a multi-level, multi-stakeholder collaborative innovation model. Based on this, the three-dimensional model proposed in this paper integrates the evolutionary trajectory of design thinking from three dimensions—cognition (systemic rationality), organization (dynamic capabilities), and technology (human-machine collaboration)—deepening its theoretical implications as a socio-technical paradigm and systematically addressing RQ1-RQ4.

This study makes several important contributions. At the academic level, it enriches the theoretical framework of the dynamic evolution of design thinking by introducing a three-dimensional interpretation of paradigm shifts. This addresses a significant gap in the literature by providing a systematic model for tracking and conceptualizing the transformation of design thinking over time. At the practical level, the study offers evidence-based, actionable pathways to guide educational reform—such as integrating design thinking into curricula to foster systematic thinking and innovation capabilities; corporate innovation—through building dynamic capabilities, implementing sustainable strategies, and exploring human–machine collaboration models; and social system governance—by promoting multi-stakeholder co-creation as a method to address complex societal problems.Despite these contributions, the study has certain limitations. One major constraint lies in the language scope of the dataset, which is limited to English-language publications, potentially omitting valuable insights from non-English sources. Another limitation is the depth and diversity of visualization methods, which could be enhanced in future research. To address these gaps, several directions are recommended. First, multilingual data integration should be pursued by incorporating literature from core journals in languages such as Chinese and German to broaden the global understanding of design thinking's evolution. Second, semantic analysis technologies, such as natural language processing (NLP), can be used to perform deeper thematic modeling and sentiment analysis to uncover hidden patterns and research orientations. Third, cross-cultural comparative studies are needed to explore how design thinking paradigms evolve across different sociocultural contexts. Fourth, operational diagnostic tools based on the three-dimensional model could be developed to evaluate the maturity of organizations or projects across cognitive, organizational, and technological dimensions. Finally, future studies should investigate the practical application and optimization of the design thinking paradigm in specific sustainability contexts, including AI governance, circular economy transformation, and resilient city construction.

In summary, design thinking is undergoing a profound expansion from tool rationality to system rationality and human-machine intelligence collaboration, continuing to provide important theoretical support and practical solutions for addressing complex challenges, driving multidimensional innovation, and promoting sustainable social transformation. Its evolution as a socio-technical paradigm is far from complete, and it will continue to

develop in the future within the dynamic balance of human-centered values, system resilience, and technological empowerment.

Ethics Approval and Consent to Participate

Not applicable

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the research, authorship, or publication of this article.

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