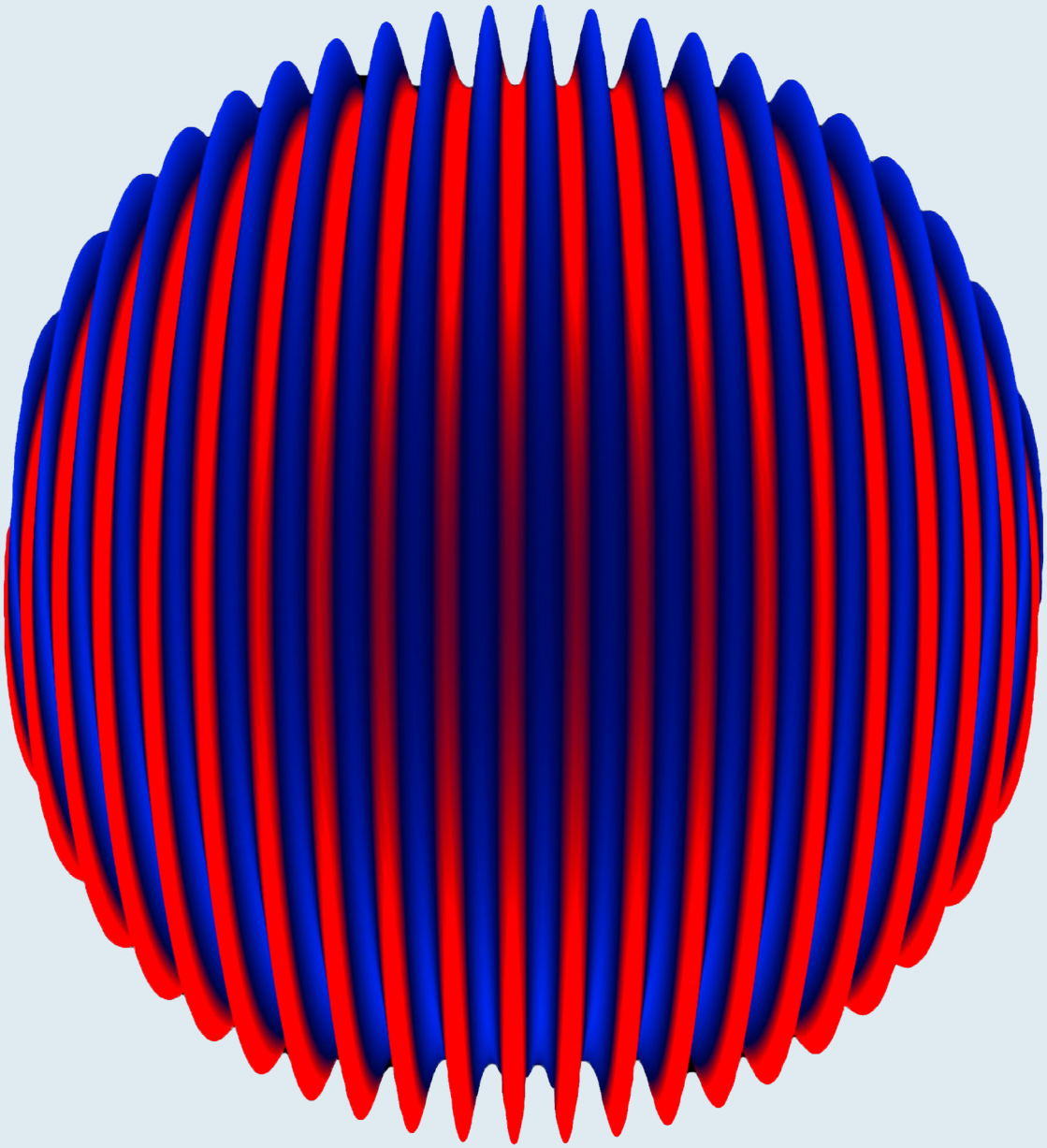

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Design Thinking in the System: Emerging Features, Contributions, and Practices

Xue Pei[1] and Laura Pirrone[1]

Abstract

Design Thinking (DT) has become a widely adopted approach for innovation in business and organizational contexts, yet it is increasingly applied to socially and environmentally oriented challenges characterized by systemic complexity. While existing literature has discussed DT features and methods extensively, less attention has been paid to how these features evolve when DT operates within complex socio-technical systems. This paper investigates how core DT features and contributions are reinterpreted in systemic contexts. Drawing on three research projects applying DT to address complex challenges, the study compares DT practices in business innovation with those applied to systemic challenges. The analysis reveals a shift from human-centredness toward stakeholder ecosystem engagement; from solution generation to systemic reconfiguration and alternative pathways; from rapid prototyping of ideas to long-term experimentation and visualization of complexity; from future thinking to shaping the shared futures; and from generating innovation outcomes toward activating processes of transformation. By articulating these evolutions, the paper contributes empirical evidence to ongoing debates on the evolution of DT and clarifies how DT practices can support navigating complexity, sense-making, coordination, and long-term change in complex systems. The findings offer insights for both researchers and practitioners seeking to apply DT beyond business innovation toward systemic transformation.

Keywords

Design Thinking, Systemic Design, Wicked Problem, Systemic Transformation, Case Study

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Institutional Affiliation

[1]Department of Design, Politecnico di Milano, Milan, Italy

Introduction

Design Thinking (DT) has gained widespread adoption in business, innovation, and organizational management for its contributions to creativity, differentiation, and value creation. Traditionally applied to developing products, services, and experiences, DT is now increasingly being used to address broader societal and environmental challenges. These complex issues, such as climate change, inequality, and sustainability transitions, are characterized by uncertainty and interdependence, and are often described as wicked problems within complex systems (Rittel & Webber, 1973). This expansion of DT into systemic contexts has raised important questions about whether approaches developed for product and service innovation are adequate for engaging with systemic complexity and long-term transformation. Although fields such as systemic design (Jones, 2014), transition design (Irwin, 2015), and design for social innovation (Manzini, 2014) have generated important theoretical contributions, the literature still lacks a clear account of how DT itself is adapted when applied at the systems level. Existing discussions often treat DT either as a general mode of designerly way of reasoning or as a prescriptive set of methods and tools. As a result, the specific ways in which DT evolves, expands, and is reconfigured in systemic contexts remain underexplored.

This paper addresses this gap by examining how core features and contributions of DT evolve when applied to socially and environmentally oriented challenges, clarifying the use of DT at the system level. Drawing on three case studies, it compares DT practices in business settings with those used in projects that address systemic change and transformation. The paper is structured as follows. Section 2 reviews the key features of design thinking and the critiques in the literature. Section 3 introduces a systemic approach to addressing wicked problems in society. Section 4 outlines the research methodology, followed by Section 5, which presents the empirical findings. Finally, Section 6 closes with the conclusion.

1. Design Thinking and the Current Critique

The features and contributions of DT have been discussed in the existing literature. In this section, we summarize the seven essential features of DT that represent its origins and recognized values.

User-centredness is a foundational feature of DT that emphasizes empathy with users to understand their needs, desires, and perspectives. Empathy enables designers to perceive problems from the user's point of view and to develop solutions that are meaningful, usable, and desirable (Brown, 2008; Norman, 2013). Within business and innovation contexts, DT fosters customer orientation that supports compelling customer experiences, organizational value creation, and competitive advantage (Gruber et al., 2015).

Abductive reasoning is designers' unique cognitive logic toward the generation of novel possibilities (Dorst, 2011). Designers propose "what might be" by iteratively framing and reframing problems in relation to emerging insights, constraints, and opportunities (Martin, 2009). Framing allows designers to define the scope, meaning, and direction of a design challenge, while reframing supports the exploration of alternative interpretations that can lead to innovative outcomes. In business and innovation contexts, this process supports the development of innovative products and services by challenging existing assumptions and enabling organizations to identify novel value propositions and achieve differentiation (Kolko, 2010).

Prototyping and fast testing are essential features of DT. They support learning through making and experimentation by enable designers to explore alternatives, test assumptions, and generate feedback early and often, as well as refining solutions through interaction with users and stakeholders (Brown, 2008). In this sense, prototyping functions as a means of evaluation as well as a mode of inquiry, enabling reflection-in-action throughout the design process (Schön, 1983). In business environments, prototyping enables experimental learning (Elsbach & Stigliani, 2018) by allowing ideas to be tested early and at low cost, helping organizations validate assumptions, gather feedback, and adjust solutions before large-scale implementation.

Within DT, creative problem-solving supports the generation of novel responses through the exploration of multiple alternatives and the synthesis of diverse insights. Through iterative cycles of divergence and convergence, designers challenge existing assumptions and move beyond routine solutions to create new products, services, and experiences (Goldschmidt, 2016). In business and innovation contexts, this capability contributes to competitive advantage by enabling organizations to develop distinctive value propositions and non-obvious solutions that redefine value and meaning, rather than merely optimizing existing offerings (Verganti, 2009).

Visualization is a central feature of DT to realize the designers' ability to enable others to see ideas and explore alternatives. Visual representations are not only a means of communication but also cognitive tools that support designers' reflection on the design as it develops. Therefore, visualization becomes a part of design reasoning and reflective practice (Cross, 2006; Schön, 1983). By translating abstract concepts into visible and manipulable artefacts, visual representations enable ideas to be discussed, evaluated, and iteratively refined by multiple actors (Brown, 2008; Cross, 2006).

Future thinking is another distinctive feature of DT that represents designers' ability to envision desirable futures and to orient innovation processes toward preferred directions. Through speculative exploration, foresight, and envisioning practices, designers articulate images of possible futures that help frame uncertainty, inform decision-making, and guide strategic intent (Buehring & Bishop, 2020). These envisioned futures provide direction for innovation efforts by helping organizations interpret emerging challenges and opportunities, aligning actions and priorities over time (Bühring & Liedtka, 2018).

DT is characterized by a holistic perspective that enables designers to synthesize multiple elements of a design situation into a coherent whole by focusing on relationships rather than isolated components. By integrating user experience, technological possibilities, and organizational and strategic considerations, this perspective supports the development of novel, robust, and meaningful solutions in business and innovation contexts (Verganti, 2009).

Beyond its widely acknowledged contributions, DT has increasingly been subject to critical examination in recent research. Cross (2023) highlights concerns about the simplification and standardization of DT practices, which risk undermining designerly ways of knowing and producing superficial outcomes that fail to engage deeply with the nature of complex problems. In socially oriented contexts, Fayard & Fathallah (2023) argue that DT is often applied within limited timeframes, resulting in interventions that lack scalability and fail to address systemic complexity. This is particularly evident in initiatives aimed at tackling challenges within interconnected social and institutional systems. Moreover, the strong focus on economic performance in business-oriented applications can marginalize DT's capacity to respond to social and environmental challenges. Addressing these limitations, Baldassarre et al. (2024) call for more comprehensive, ethically grounded DT approaches by integrating responsible innovation principles.

2. Wicked Problems and the Emergence of Systemic Approaches in Design

Contemporary societies are confronted with complex challenges that are socially and environmentally oriented, deeply entangled, and situated within complex systems resisting straightforward problem-solving approaches. Such challenges are often described as wicked problems: problems characterized by incomplete, contradictory, and continuously evolving requirements, and by the absence of clear problem boundaries or definitive solutions (Rittel & Webber, 1973). They are inherently socially complex and have no clear endpoint. Efforts to address one part of the problem often expose or generate new difficulties in other areas of the system, and interventions can unintentionally set off further complications (Tonkinwise, 2015). These phenomena are multi-level and multi-actor, involving dynamic interactions between technological innovation, behavioural change, institutional structures, and policy frameworks (Geels, 2002; Jones, 2014). Their complexity challenges conventional problem-solving approaches that assume linear causality, stable boundaries, and clearly defined objectives.

In response to this context, DT has increasingly evolved toward systemic orientations capable of engaging with complexity. This evolution stretches the designerly ways of knowing, thinking, and acting toward practices that acknowledge interdependence, emergence, and uncertainty. DT, therefore, moves beyond a problem-solving methodology toward a way of acting within complex and problematic situations (Cross, 2023). Within this shift, systemic design has emerged as an interdisciplinary approach that integrates systems thinking with design practices and methodologies. Systemic design frames problems as systems of interconnected elements rather than isolated challenges, and develops interventions that attend to the broader context and potential consequences (Bijl-Brouwer & Malcolm, 2020; Ryan, 2014).

Although DT is actively applied in practice and widely discussed in the literature, knowledge about how its features are evolving and being reinterpreted to address complex social and environmental challenges remains fragmented. This paper, therefore, explores the evolution of DT and investigates the following research questions: 1) How does DT evolve when applied to socially and environmentally oriented challenges situated within complex socio-technical systems? 2) How are core DT features and principles, largely articulated in business and innovation contexts, reconfigured when addressing socially and environmentally driven design problems?

3. Practising Design Thinking in Systems

We conducted participatory action research (Ozanne & Saatcioglu, 2008) across three projects that applied DT to address complex challenges over the past five years. In each case, fostering transformative change was a central objective. Across the three cases, the researchers adopted an active role as researchers, facilitators, and designers, contributing to the definition of methodological frameworks, the structuring of collaborative processes, the engagement of stakeholders, and the support of sense-making and experimentation through DT methods and tools. These three cases were selected as different but comparable socio-technical systems undergoing sustainability transitions. They differ in scale (local to international), maturity (exploratory to implementation-oriented), and stakeholder configurations, enabling a richer understanding of how DT is applied to address systemic change across contexts.

Case study 1: Longevicity - designing for walkability in the urban context. drThe project explored how to promote the social inclusion of elderly people living in urban environments by enhancing active walking. Walkability is an issue related to a broader socio-technical system (public services, urban infrastructure, community networks, and everyday practices), therefore, the work engaged multiple stakeholders throughout the process, including academic institutions and researchers, social service providers (organizations and staff), volunteers, public institutions, and elderly citizens. DT methods and tools were used to involve elderly people (and their families), social service providers, volunteers, and relevant public institutions to understand existing challenges, expectations, and constraints. System mapping played an important role in enabling this alignment across diverse actors and system levels by making relationships and interdependencies within the system visible. Stakeholders were also encouraged to participate in hands-on making activities to co-create shared scenarios for "walkable" urban contexts. The design interventions did not lead to rapid validation of a single solution; instead, they generated multiple proposals (product and service ideas) that were used to discuss, adapt, and iterate as part of ongoing systemic experimentation. These proposals were shared with the elderly community, service providers, and public institutions as a starting point for continued dialogue on how the interventions could catalyse change and contribute to the longer-term transformation of the urban context.

Case study 2: R-evolve: designing for circular transformation in the furniture sector. The ongoing project aims to support the transition of the furniture sector towards a circular ecosystem through circular design strategies, circular business models, and a digital product passport. Circular transition is complex and long-term. The work needs

to engage multiple stakeholders across the value chain, including furniture manufacturers and their partners (retailers, material suppliers, and logistics providers), industry associations, policymakers, business clients, and final consumers. DT was applied as both a mindset and a practical guide to support collective sense-making across actors with different roles, incentives, and constraints. In the first year, the focus was on framing and reframing the challenge from an ecosystem lens: building a shared understanding of current practices and barriers to circularity before proposing specific interventions. DT methods and tools were used to connect micro-level practices (e.g., design and material decisions) with meso-level (e.g., company strategies and service networks) and macro-level conditions (e.g., policy and market changes), which helped reframe several briefs initially brought by the companies. The project now focuses on circular business model experimentation with eight European furniture companies, prototyping initiatives and interventions intended to drive changes within organizations and contribute to transition at the systemic level.

Case study 3: Towards smart and circular waterborne passenger mobility (WPM) ecosystems: a systemic and strategic approach. The project explored the transition of the WPM sector toward more sustainable and digitally enabled models by reframing it as a complex socio-technical ecosystem. Building on ten case studies, the work engaged multiple stakeholders across the system, including mobility operators, public authorities, technology providers, and service partners. DT methods were used to investigate current practices, challenges, and opportunities related to sustainability and digitalization, supporting an iterative process of framing and reframing the ecosystem. Interviews, system mapping, and scenario-building activities enabled stakeholders to develop a shared understanding of actor relationships, system dynamics, and value creation. Three Strategic Directions were co-developed, each outlining a pathway toward sustainability through specific ecosystem configurations, roles, and value propositions. DT tools supported coordination across micro (passenger services), meso (organizational relationships), and macro (urban mobility governance) levels, while prototyping value exchange flows and visualizations facilitated collective sense-making and alignment. Rather than converging on a single solution, the project generated strategic proposals to support ongoing experimentation and guide the long-term transformation of the WPM ecosystem.

4. Research Findings: Emerging Features and Practices of Design Thinking in Systems

In this section, we report empirical findings on the evolution of DT's essential features from a systemic perspective. Building on evidence and experience from three case studies, we compared DT features and contributions practised in business settings with DT applied to projects tackling complex social problems.

4.1. From Human-centred to stakeholder-engagement in the ecosystem

When DT is applied to socially and environmentally oriented challenges within complex systems, its traditionally human-centred focus is reinterpreted toward engaging a broad range of heterogeneous stakeholders, including actors with diverse and often conflicting interests as well as non-human entities such as infrastructures, technologies, and ecological systems (Irwin, 2018). Empathy becomes a critical tool for navigating and negotiating needs, expectations, and values of multiple actors within an ecosystem. Design decisions and interventions aim not only at addressing personal needs but at fostering shared values and collective responsibilities across communities, organizations, and socio-technical systems (Jones, 2014; Manzini, 2015). To enable this engagement, DT practices commonly employ tools such as stakeholder, actor-network, and ecosystem maps, which support the identification of actors and their interrelationships and provide a basis for collective sense-making and dialogue. This approach differs from conventional applications of DT in business, where the process typically begins by identifying and prioritizing the individual user's needs and desires. In systemic contexts, the mapping of stakeholders is a foundational activity that enables mutual understanding and opens up possibilities for conversations.

4.2. Reframing for creating a shared understanding and value proposition

When DT addresses complex challenges, abductive reasoning emerges as a collective and collaborative practice. Framing and reframing shift from individual cognitive activities aimed at producing business offerings to shared sense-making processes that help stakeholders navigate complexity across multiple system levels. Rather than being limited to specialized expertise, framing becomes a collective and iterative activity that moves across micro, meso, and macro scales through ongoing negotiation of system boundaries (Goss et al., 2025). In such settings, reframed value propositions emerge through alignment and coordination among actors within socio-technical systems (Vargo & Lusch, 2017). Accordingly, design interventions focus on reconfiguring relationships, structures, and resource flows, enabling gradual transformation rather than one-off solutions (Geels et al., 2023). Reframing is among the most challenging activities in DT, particularly in sys-

temic contexts, as it requires advanced facilitation skills and effective stakeholder involvement. This highlights the need for more concrete and actionable methods and tools to support collective reframing processes.

4.3. Prototyping intangible artefacts: systems and relationships

When DT is applied to complex challenges, prototyping becomes a form of systemic experimentation rather than a means of rapid solution validation. Prototypes are used to test partial and provisional interventions, explore how they interact with existing socio-technical structures, and learn from their effects over time (Jones, 2014). Prototyping in a systemic context is not a short sprint typically used in business innovation and startup launches; instead, it is more like a marathon journey in which different stakeholders continuously work together, trying different initiatives and possibilities and gathering feedback quickly and flexibly. This iterative process unfolds across extended timeframes and multiple system levels, shifting the focus from optimizing isolated elements to reconfiguring relationships, resource flows, and institutional arrangements (Hillgren et al., 2011; Goss et al., 2025). Prototyping thus becomes a means of enabling gradual transformation through learning-in-action, rather than a pathway to rapid convergence on concrete solutions. Minimum Viable Ecosystem (Konietzko et al., 2024) is a tool for prototyping in a systems context.

4.4. Form-giving of alternatives instead of creative solutions

When DT engages with complex challenges, its creative problem-solving feature is reinterpreted as a practice of systemic reconfiguration rather than solution generation. Creative activity focuses on exploring alternative ways of organizing relationships, roles, and resource flows within socio-technical systems (Drew et al., 2024), assembling decentralized initiatives into coordinated configurations that give form to alternative visions and narratives of change (Pei, 2024). In this context, problem-solving becomes a collective and exploratory process, and design proposals function as provocations that enable gradual and adaptive transformation through learning and coordination rather than prescribed solutions (Jones, 2014).

4.5. Visualizations to facilitate conversation and sharing

Within the systemic context in which DT is applied, visualization is reinterpreted as a practice of sense-making and alignment within complex socio-technical systems. Rather than primarily making individual ideas tangible, visual representations are used to render relationships, interdependencies, and system dynamics visible across actors and scales, supporting collective understanding without reducing complexity and facilitating dialogue around roles, value exchanges, and potential intervention points. Visualization also enables the exploration of multiple perspectives, supporting collective framing and reframing processes that open up new pathways for addressing complex problems (Bijl-Brouwer & Malcolm, 2020). Practices such as system mapping and giga-mapping function as shared cognitive and collaborative spaces, allowing designers and stakeholders to switch among different system scales, towards aligning perspectives, negotiating meanings, and coordinating action (Sevaldson, 2011).

4.6. Collective future-making among stakeholders beyond the company

When dealing with complex challenges, future thinking is reinterpreted as a collective and negotiated practice of imagining shared desirable futures. Instead of projecting a company-centric vision, DT engages multiple stakeholders in articulating and negotiating diverse future imaginaries shaped through dialogue across actors, values, and temporal horizons within systemic contexts. In this setting, future visions do not function as fixed targets but as boundary objects that support collective sense-making, coordination, and orientation toward long-term change (Mark et al., 2007). Practices such as scenario building and road mapping provide infrastructures for collective future making by enabling stakeholders to explore alternative trajectories, examine implications across system levels, and align around shared directions of change while leaving space for adaptation and learning. Compared to business-oriented applications that often focus on anticipating market shifts and designing offerings to compete, DT in systemic challenges uses its envisioning capacity to embrace plural perspectives for co-imagining a shared future and shaping new approaches and pathways that can sustain coordinated action and long-term transformation (Drew et al., 2024).

4.7. A holistic perspective for "transformation" rather than "innovation"

When DT addresses complex challenges, its holistic perspective shifts from integrated innovation outcomes toward systemic transformation. In complex problem contexts, systems evolve over time and interventions in one area inevitably produce consequences elsewhere (Bijl-Brouwer & Malcolm, 2020). DT practices, therefore, move beyond optimizing bounded problems to engaging with how system dynamics should evolve to support shared values among heterogeneous stakeholders. In this interpretation, a holistic perspective enables a comprehensive understanding of complexity while facilitating collective articulation of long-term objectives and directions

(Pei, 2024). Designers attend to how interventions interact across system levels and how change unfolds through feedback, adaptation, and coordination among multiple actors. DT practices thus shift toward enabling long-term, multi-level change across interconnected social, technical, and institutional domains. This transformation extends beyond discrete innovation outcomes, prioritizing systemic change over short-term optimization.

Discussion and Conclusion

The research findings indicate that when DT is applied to complex social challenges within broader systems, its origins and core features evolve and should be reinterpreted. While DT continues to demonstrate the value and contributions discussed in the literature, in systemic contexts these strengths need to be reframed to support collaboration, deal with complexity, and sustain long-term change. Figure 1 summarizes these evolving shifts, highlighting how core features of DT are reconfigured when addressing complex, multi-stakeholder, and socio-technical challenges. It illustrates how DT's features and principles are redefined to better align with the demands of systemic change. Human-centredness extends to broader stakeholder engagement across ecosystems; framing and reframing become collective processes of sense-making and alignment; prototyping aims to experiment with long-term systemic changes; and creativity shifts from solution generation to the form-giving of alternative configurations of relationships, roles, and resource flows. In parallel, visualization and future scenario building function as shared infrastructures for dialogue and conversations towards the co-construction of new meanings. A holistic perspective reorients DT from innovation-driven outcomes toward enabling ongoing transformation. Together, these elements converge into a coherent practice that supports learning-in-action, negotiation among diverse actors, and the gradual reconfiguration of socio-technical systems, suggesting that DT in systemic contexts should be understood not as a sequence of methods, but as an integrated and evolving capability for orchestrating transformation across multiple levels and stakeholders.

This study contributes to DT research by providing empirical evidence of how foundational features evolve when DT moves towards systemic applications. Rather than proposing a new model or prescriptive framework, the paper offers a comparative lens that clarifies how DT's contributions shift from producing discrete innovation outcomes towards enabling processes of systemic transformation.

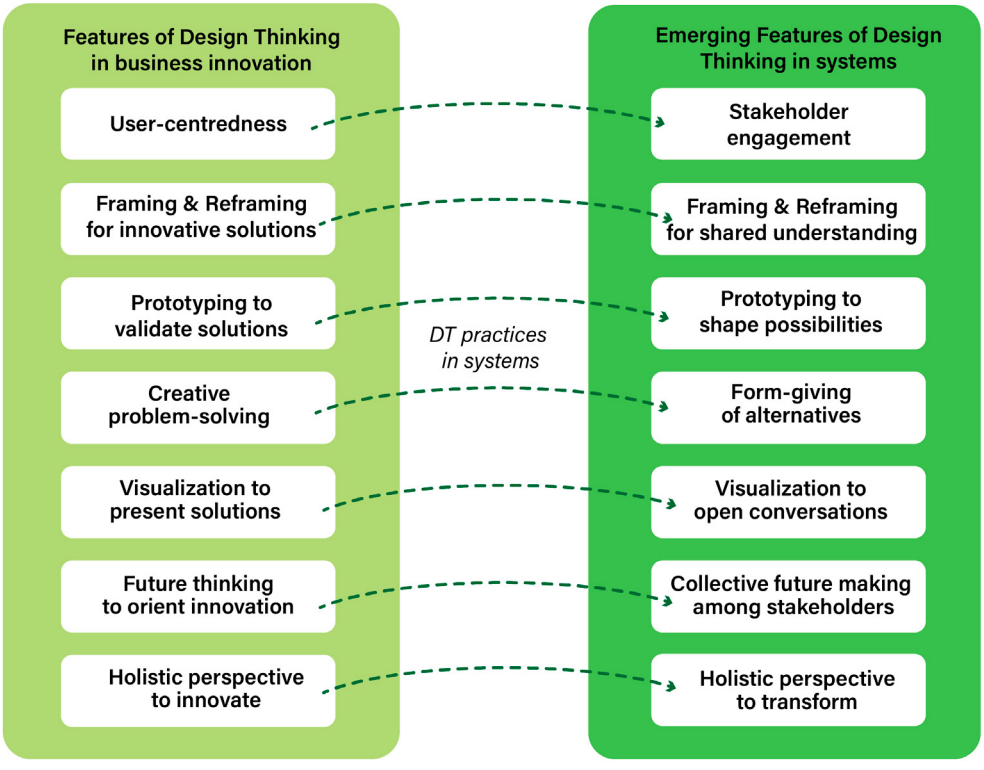

Fig. 1. Evolution of Design Thinking core features from business innovation to application in systems (developed by the authors)

The findings provide insights for both researchers and practitioners seeking to apply DT beyond innovation toward systemic change.

Future research could explore how integrating systemic perspectives contributes to redefining DT, particularly by examining how established frameworks (e.g., the Systemic Design Framework (Design Council, 2026)) are being adapted to address systemic challenges. Further investigation should focus on developing and testing methods that support collective framing and decision-making in systemic contexts, as well as examining how DT practices transfer across different sectors and cultural settings. Moreover, future research should examine how designers' roles and responsibilities evolve as DT shifts toward long-term systemic transformation.

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In a time marked by technological disruption, ecological collapse, and systemic inequality, critically rethinking Design Thinking is necessary. DTRS'15: Design [Re]Thinking is a symposium dedicated to examining the evolution of Design Thinking and its relevance in addressing contemporary societal and environmental challenges. Hosted in Lisbon, Portugal, it was organised through a collaboration between the research centres FBAUL/CIEba, ID+, and UNIDCOM/IADE, together with non-academic partners.

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