

Ambidextrous Management of Design in the Age of Artificial Intelligence - Driven Digital Innovation: A Narrative Review

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Abstract

Design is increasingly understood as a sociomaterial practice in which human actors and material agencies co-produce problem solving and meaning in evolving sociotechnical systems. This narrative review synthesizes fragmented work on generativity and generative design and traces how organizational design languages have shifted from control- and governance-oriented approaches toward enabling, open, and collaborative forms of organizing. Drawing on classic cases from Xerox PARC and Frank O. Gehry's technology-enabled architectural practice, and on theories of digital materiality and layered modular architecture (LMA), the paper shows how digital artifacts remain incomplete and recombinable while generative AI amplifies both generative capacity and sociotechnical risk (e.g., overload, homogenization, privacy, and accountability challenges). This paper advances an ambidextrous view of design management for AI-driven digital innovation: organizations should enable generativity while deploying nuanced, human-centered controls - including governance, formalization, and interdisciplinary oversight—to steer evolving design practices toward accountable and ethically defensible outcomes.

Keywords: Digital materiality, Generativity, Design management, Sociomaterial practice, Digital innovation, Artificial Intelligence (AI), Generative AI (GenAI), Human-centered design

1. Introduction

Moving beyond the traditional view of design as aesthetics or form-giving (Yoo, 2012), contemporary scholarship increasingly conceptualizes design as a sociomaterial practice in which human action and material agency jointly shape problem solving in complex artificial systems (Leonardi, 2012; Leonardi & Rodriguez-Lluesma, 2012; Simon, 1996). Design, in this sense, is dedicated practice for creating new meanings through ongoing social interaction among stakeholders and diverse technical systems—products, services, organizations, and infrastructures—embedded in open systems of exchange between organizations and their environments (Bannon & Ehn, 2012; Scott, 1998; Verganti et al., 2021).

Historically, design methods have been aligned with linear, hierarchical, and control-oriented organizational languages suited to closed-system management run by professional designers (Scott, 1998; Yoo, 2012). As digital technologies increase the complexity and interconnectedness of design work, organizations increasingly rely on decentralized and collaborative approaches that engage heterogeneous stakeholders to identify user needs and renew existing artifacts—an orientation captured by the concept of generativity (Krippendorff, 2011; Verganti, 2008; Yoo, 2012).

The rapid diffusion of AI, particularly generative AI (GenAI), intensifies this shift and raises foundational questions about human-centered design and the roles of “design by humans” and “design for humans.” AI tools based on large language models (LLMs) are reshaping design problem solving, expanding generative potential, and reconfiguring sociotechnical arrangements (Cai et al., 2026; Sreenivasan & Suresh, 2024; Verganti et al., 2020). These developments extend design thinking (DT) and collective creativity beyond professional designers, reinforcing the ambition of design-driven, sociotechnical system-level innovation (Bannon & Ehn, 2012; Verganti, 2008).

Despite growing attention to AI-enabled design innovation, the literature remains fragmented. Digital innovation management research has examined generativity primarily at the sociotechnical system level (e.g., institutional and ecosystem change) (Orlikowski & Scott, 2023; Thomas & Tee, 2019; Yoo et al., 2024), while design research more often emphasizes AI within technical-system design processes such as DT and prototyping (Verganti et al., 2020; Sreenivasan & Suresh, 2024). A sociomaterialist account of how AI-powered design innovation should be managed under rising sociotechnical complexity in organizational settings is still limited.

Accordingly, this narrative review adopts a sociomaterialist lens to address three research questions: (RQ1) how conceptions of design transform with technological integration in complex design processes; (RQ2) how organizational design languages evolve as design itself changes; and (RQ3) what design signifies—and how design activities can be effectively managed—in organizational contexts in the AI age.

- RQ1: In what ways has the concept of design transformed with the integration of technology into intricate design processes?
- RQ2: How have organizational languages in design within complex design practices shifted or developed as the concept of design itself has evolved?
- RQ3: What does design signify, and how can design activities be effectively managed within real organizational environments in the AI age?

To answer these questions, the review traces the development of generative design from early sociomaterial practices at Xerox PARC (Palo Alto Research Center), through Gehry’s technology-enabled architectural processes, to contemporary digital ecosystems organized through layered modular architecture (LMA) and increasingly shaped by AI. It argues that managing design in this context requires ambidexterity—enabling generativity while sustaining human-centered control (Eaton et al., 2011; Farjoun, 2010; Yoo et al., 2024).

Given the conceptual breadth and interdisciplinary fragmentation of the literature, this study adopts a narrative review approach. The review was initially oriented by foundational sociomaterial scholarship, especially the body of work assembled in *Materiality and organizing: Social interaction in a technological world* edited by Leonardi et al. (2012). From this starting point, the search was expanded in Google Scholar using combinations of the following terms: Digital materiality, Generativity, Design management, Sociomaterial practice, Digital innovation, Artificial Intelligence (AI), GenAI, and Human-centered design.

The search strategy combined keyword searching with citation tracking to clarify how concepts of design, generativity, and digital materiality have evolved across related fields. Seminal works by authors such as Suchman et al. (2002), Verganti (2008), Orlikowski and Scott (2008), Yoo (2012), and Leonardi (2012) were used as anchor texts. Relevant studies citing, extending, or conceptually engaging with these works were then examined to identify recurring themes, theoretical linkages, and shifts

in organizational approaches to design. This iterative search logic informed the analytical framework that guides the narrative review (Figure 1).

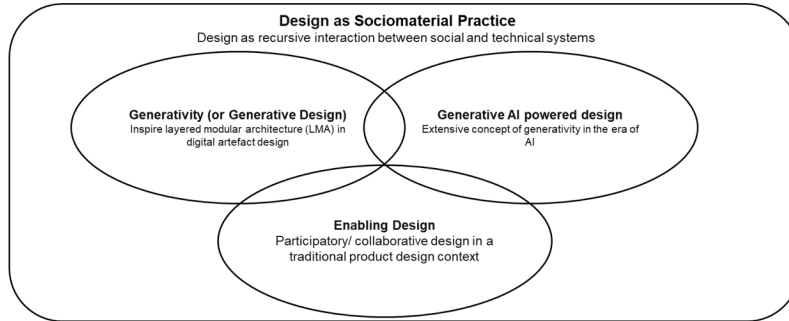


Figure 1 Analytical framework for the narrative review

2. Changing Approach to Managing Design: From Controlling to Generativity

2.1 Design as Sociomaterial Practice

Early organizational accounts often treated design as a largely internal, technical activity coordinated through centralized, control-oriented “design languages” within relatively closed systems (Scott, 1998; Yoo, 2012). Under this view, professional designers and key decision-makers governed design work through hierarchical structures and standardized procedures.

Subsequent research broadened this framing by examining how design practices become accessible to—and shaped by—heterogeneous internal and external stakeholders in pursuit of sociotechnical system-level innovation (Bannon & Ehn, 2012; Verganti, 2008; Yoo, 2012). From a sociomaterial perspective, design is produced through the ongoing imbrication of social relations and material elements (e.g., artifacts, tools, and technical guidance) as participants negotiate what the design is and should do (Leonardi, 2012; Leonardi & Rodriguez-Lluesma, 2012). In product and service design, these interactions using design languages help align usability, functionality, and intended meanings (Adler & Winograd, 1992).

Accordingly, design emerges at the intersection of situated human activity and material constraints, while also reflecting broader institutional and societal expectations. As Suchman and Blomberg (2002) shows, even highly technical design work must be oriented to everyday work practices and user needs as well as to formal requirements and specifications. Building on this sociomaterial understanding, the next sections examine how organizational “design languages” evolve from controlling to more generative forms, using prototyping cases to illustrate the shift.

2.2 Design Prototyping as the Manifestation of Organizational Design Languages

2.2.1 Formalization in Design Prototyping: Controlling vs. Enabling

To distinguish how organizational environments shape “design languages,” Adler and colleagues show that routine design activities such as prototyping are inherently sociomaterial: they embed material artifacts and tools in organizational interests and control systems (Adler & Borys, 1996; Adler & Winograd, 1992). Based on ethnographic observation of photocopier prototyping at Xerox PARC in the early 1990s, Adler and Borys (1996) explain how formalization structures interactions among designers, users, and managers and, in turn, shapes design outcomes.

In bureaucratic organizations, formalization refers to the rules, documentation, reporting routines, and repositories through which information is processed and decisions are coordinated (Mintzberg, 1979; Scott, 1998). In design prototyping, these mechanisms can reduce ambiguity and make risks legible for decision-makers, but they also embed expectations about who can participate, what counts as valid evidence, and how design work should proceed (Adler & Borys, 1996; Suchman & Blomberg, 2002).

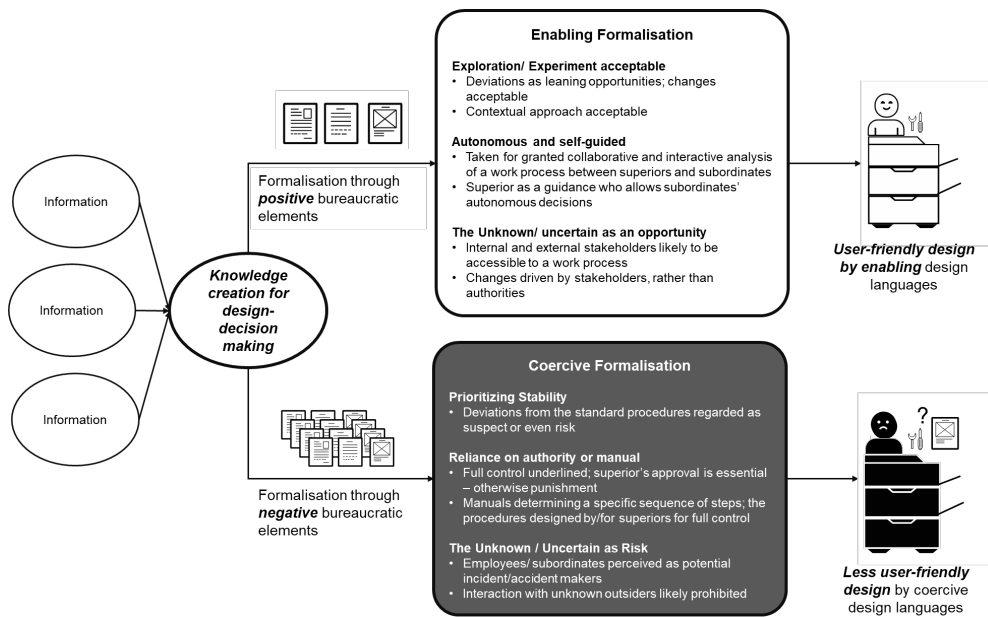


Figure 2 Design decisions made by different design languages: Coercive and Enabling Formalization (Adapted from Adler & Borys, 1996; Scott, 1998)

Formalization can therefore support learning and accountability while simultaneously operating as behavioral control that standardizes work practices (Mintzberg, 1979; Scott, 1998). Building on this insight, Adler and Borys (1996) distinguish two ideal types of formalization in prototyping that lead to markedly different design trajectories (Figure 2).

First, *coercive* formalization relies on one-way, controlling organizational language that prioritizes compliance with rules and hierarchical oversight (Adler & Borys, 1996). In prototyping, this can discourage experimentation and limit meaningful user involvement, because collaboration is treated as a source of uncertainty (e.g., information exposure). The result is often weaker feedback loops and less user-friendly designs. A frequently cited illustration is authoritarian, hierarchy-heavy new product development (NPD), where multiple reporting layers constrain exploration. For example, accounts of Samsung’s NPD culture during heightened smartphone competition describe consensus-driven reporting and risk-averse decision making that favored fast-following, market-oriented outputs over user-centered experimentation (Cain, 2020; Wilson, 2015).

This environment has been associated with recurring design controversies, including high-profile copying allegations and the Galaxy Note 7 battery failures that led to flight bans in the U.S. (Cain, 2020).

Second, *enabling* formalization highlights the productive side of bureaucracy by using rules and artifacts to support collaboration, reflection, and iterative learning (Adler & Borys, 1996). In prototyping, enabling structures create shared reference points (e.g., templates, repositories, boundary objects) that make participation easier for heterogeneous stakeholders and sustain exploratory cycles—conditions consistent with a design-thinking ethos (Schrage, 1996; Elsbach & Stigliani, 2018). By broadening who can contribute and how feedback is incorporated, enabling formalization strengthens the generative potential of design work; Xerox PARC’s prototyping practices provide a foundational illustration of these dynamics.

2.2.2 Lessons from Xerox PARC Projects

Xerox PARC's interdisciplinary research—especially collaborations between anthropology and computer science—has been central to sociomaterial understandings of design and information systems and has influenced later design research in firms such as Apple (Blomberg & Burrell, 2009; Suchman et al., 2002).

PARC projects show how organizational work emerges through the ongoing interplay of social coordination and material arrangements. For example, Suchman's et al. (2002) ethnomethodological study of a Department of Highways project at Xerox PARC examines a prototyping effort to build a computer-based repository system through close observation of everyday document work. The case demonstrates that design decisions arise from situated practice and that prototypes must align with how people find, classify, and share documents in the workplace. A key challenge was moving from a long-established paper repository organized through the Uniform File System (UFS)—a standardized classification scheme used across the department—to a digital repository. Although the UFS was intended to manage diverse engineering documents, the study found a critical mismatch between its classificatory logic and people's situational practices for locating and handling documents. Consistent with Adler and Borys's (1996) account of prototyping, the case presents technology development as an ongoing interaction between social agencies (designers, users, managers) and material agencies (classification schemes, documents, and the emerging digital repository), rather than as a linear implementation process.

Taken together, these cases highlight the recursive interactions between social and technical systems that constitute complex work practices and reinforce sociomaterial theories of design (Leonardi & Rodriguez-lluesma, 2012). They also show why enabling, collaborative design languages—supported by artifacts, templates, and shared repositories—can increase the generative potential of complex design practices such as prototyping by broadening participation and sustaining iterative learning. This provides a bridge to the paper's discussion of generative design.

Related research extends this insight beyond prototyping by showing that routine activities such as information searching, documenting, and coordinating are enacted through inseparable sociomaterial arrangements of people and digital systems (Orlikowski & Scott, 2008, 2016). Across contexts, material arrangements do more than support work; they actively shape what work becomes and how accountability is defined. This perspective also applies to digital materiality at the

sociotechnical system level, where the spread of digital materiality across social and institutional settings drives subtle institutional change. For example, downloadable digital books have begun to unsettle standards tied to physical publishing formats, such as the ISBN, while traditional hotel accreditation based on formal inspections is increasingly being displaced by online reviews and algorithmic rankings on platforms such as TripAdvisor (Orlikowski & Scott, 2023).

In sum, the PARC prototyping cases show how enabling design languages broaden participation and sustain iterative learning—conditions that make design more open-ended and recombinable. To explain how this openness scales beyond local prototyping into wider digital ecosystems, the next section introduces generativity as a core mechanism through which evolving sociotechnical systems produce new design possibilities and reconfigure digital materiality.

2.3 Generative Design in Creating Digital Materiality

2.3.1 Generativity

As digital technologies advance and product-service systems become more complex, design as a sociomaterial practice increasingly depends on organizational design languages that emphasize openness, participation, and continual adaptation. Within design management and information systems research, this shift is commonly theorized through generativity—the capacity of a design setting to enable new contributions, recombinations, and outcomes beyond what designers can fully anticipate (Kallinikos et al., 2013; Yoo et al., 2010).

Generativity has been used to frame the evolution of artificial systems ranging from engineering artifacts and architectural projects to digital products and services. In engineering design, it is often treated narrowly as the relationship between a physical product system and its functional attributes, defined by design parameters within a relatively closed system (Baldwin & Clark, 2000; Bordas et al., 2024). By contrast, design and management studies adopt a broader sociomaterial view in which generativity is recursive, iterative, and open-ended: new meanings and human experiences emerge through multilevel interactions among social and technical elements (Krippendorff, 2011; Verganti, 2008). Management scholarship likewise characterizes generativity as a capacity to generate and evoke creation in practice (Avital & Te'eni, 2009; Thomas & Tee, 2019; Yoo et al., 2006). Rather than producing a final, closed solution, generative design activities yield provisional artifacts that remain incomplete and are continuously revised through co-creation—especially in digital contexts (Garud et al., 2008; Nylén & Holmström, 2015; Thomas & Tee, 2019).

Thomas and Tee (2019) therefore conceptualize generativity at the level of sociotechnical systems, where social actors (e.g., designers and users) and technical components (e.g., digital products and services, digitized infrastructures, and institutions) interact to enable combinatorial innovation (see also Yoo et al., 2010). This view foregrounds the distributed, recombinable nature of digital artifacts and helps explain why generative design increasingly depends on coordinating participation across organizational and ecosystem boundaries.

2.3.2 Architectural Design Project Inspiration: Lessons from Organizational Design of Gehry Partners, LLP

Generative design has been developed extensively in design management research through close studies of Frank O. Gehry's projects at Gehry Partners, LLP, which show how organizational arrangements and representational technologies jointly enable generative form-giving (Avital & Te'eni, 2009; Yoo et al., 2006).

Studies of Gehry's work emphasize a strong *design gestalt*¹ as a generative force that anchors the firm's architectural outcomes and guides its organizational design (Yoo et al., 2006). This gestalt is enacted through: (1) a coherent architectural vision; (2) sustained collaboration among key stakeholders (social agencies) across the architecture, engineering, and construction (AEC) industries; and (3) a portfolio of representational tools for prototyping, including physical models, 3-D digital models (e.g., CATIA), and 2-D drawings (Boland et al., 2007; Yoo et al., 2006) (Figure 4).

Within this configuration, Gehry's abstract sketches (Figure 3) are tightly coupled with physical models, 3-D digital models (CATIA), and 2-D drawings through isomorphic mappings across representations. The sketches capture early abstractions that orient exploration and evoke an initial sense of the building's form, while successive representations stabilize, test, and refine that vision through iterative feedback (Boland et al., 2008; Yoo et al.,

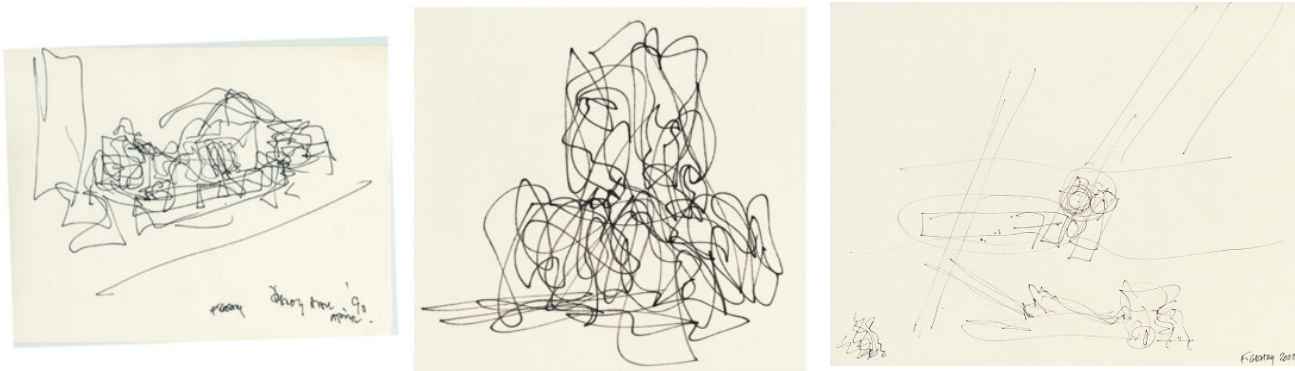


Figure 3 Gehry's abstract sketch (Bredekamp, 2025)

¹ Design gestalt refers to forms of design which emphasize the sense of an underlying "whole". This is allowed for one to recognize a "family resemblance" among variant designs, through the simultaneous co-existence of unity and variety – for example, sharing a sense of consistent product identity within a same product line (e.g. Apple products); an individual recognises a complete object from a blurred background or incomplete object figure. Yoo et al., (2006) highlight that gestalt in organization designing is an organization's ability to approach its design problems creatively and individually from a holistic and systems perspective, approaching design process and organisation not separately as maintaining a unity across design outcomes.

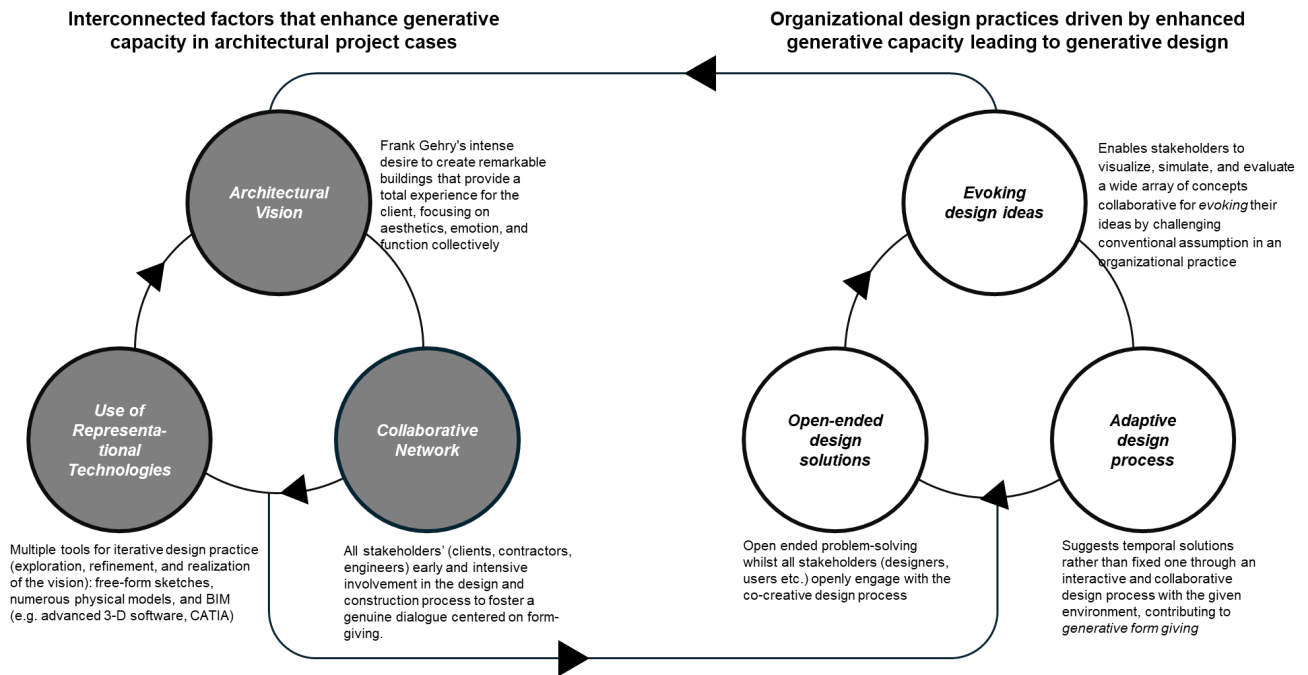


Figure 4 Interdependent elements that facilitate generative design in organization (adapted from Avital & Te'eni, 2009; Yoo et al., 2006)

2006). Across four projects - the Fish Sculpture, Guggenheim Bilbao, EMP, and the Peter B. Lewis Building (Figure 5) - research shows how these tools enable decentralized collaboration among diverse stakeholder groups and stimulate design ideas through adaptive prototyping cycles (Elsbach & Stigliani, 2018; Yoo et al., 2006). Overall, the Gehry cases illustrate how generative form-giving is enabled by organizational design that combines a shared vision with flexible, technology-mediated collaboration—shifting from “organization design” toward ongoing “organization designing” as projects evolve (Yoo et al., 2006). They also demonstrate how advanced digital modeling capabilities can expand what is representable and buildable, informing later research on building information modeling (BIM) and digital innovation in the built environment (Avital & Te'eni, 2009; Merschbrock & Munkvold, 2012). These insights set up the next section, which explains how digital materiality and layered modular architecture (LMA) generalize generativity to digital artifacts operating in distributed ecosystems.

2.4 Layered Modular Architecture (LMA) and Digital Materiality: Managing Generative and Heterogeneous Artifact Design

Building on the generativity perspective developed in the Gehry cases, digital innovation research explains generativity as a key driver of digital innovation in sociotechnical systems (Yoo et al., 2010). This view aligns with core properties of digital artifact design—open-endedness, incompleteness, heterogeneity, human-centered value propositions, and continual reconfiguration (Nylén & Holmström, 2015). To make these properties analytically tractable, Yoo et al. (2010) propose *layered modular architecture* (LMA), a modularity-based account of how digital materiality is organized and how generativity can propagate across layers.

Modularity theory, rooted in Simon's (1996) account of complex systems as “nearly decomposable,” has long informed research on technological innovation and product architecture. In classic modular architecture, complex products are built from standardized physical modules with



Figure 5 Gehry's architectural design projects: Guggenheim Bilbao (left above), Fish Sculpture (right above) (BBC News, 2025), Peter B. Lewis Building (right middle) (CSU Center for Public History and Digital Humanities, 2010), and EMP (bottom) (Savard Architecte, n.d.).

defined interfaces and interdependencies (Baldwin & Clark, 2000; Sanchez & Mahoney, 1996). Xerox’s 1990s photocopiers exemplify this single-hierarchy product architecture, where design work largely optimizes physical form and functional attributes within relatively stable constraints (Yoo et al., 2010).

By contrast, LMA explains digital artifacts as layered, loosely coupled systems that integrate tangible components (hardware, devices, and networks) with intangible components (software, services, and content). These heterogeneous layers are connected through digitized data that functions as a binding mechanism across components (Kallinikos et al., 2013; Yoo et al., 2010). Because layers can be recombined and reprogrammed by multiple actors, LMA is typically embedded in a digital ecosystem in which designers, developers, complementors, and users iteratively extend and adapt digital artifacts. Smartphones illustrate this logic: operating systems (iOS, Android), platforms (e.g., Google), and applications (e.g., TikTok, Instagram) co-evolve through distributed participation. In this setting, digital artifacts are introduced as intentionally incomplete and continually reworked through sociomaterial practices that generate new meanings and value (Yoo et al., 2010).

However, early work on generativity in digital innovation and design management has tended to emphasize benefits such as autonomy, self-regulation, and spontaneity (Yoo et al., 2010, 2024), while giving less attention to downside risks and externalities. This limitation becomes more consequential as AI-enabled sociotechnical systems—especially GenAI— increase the scale, speed, and opacity of generative design work, motivating the paper’s turn to ambidextrous control and governance in Section 3.

3. Managing Design in the Era of Artificial Intelligence (AI)-Powered Innovation: Ambidexterity between Generativity and Control

Building on the discussion of LMA and digital materiality, recent research in digital innovation and design management has increasingly examined how AI-embedded technologies—especially GenAI—reshape design and innovation work by expanding the scope of generative design practices.

Artificial intelligence (AI) refers to computational techniques that perform tasks, which mimics human cognitive system (Sreenivasan & Suresh, 2024). Contemporary AI is largely powered by deep learning, and, for many applications, large language models (LLMs) trained on

Table 1. Contrasting traditional product design and digital artifact design (adapted from Baldwin & Clark, 2000; Yoo et al., 2010)

Design dimension	Traditional product design	Digital artifact design
Architecture and material composition	- Single-hierarchy product architecture; modular architecture built from uniform physical modules (e.g., photocopiers). - Primarily tangible, physical materials; form and physical attributes dominate – a range of hardware product designs: e.g. photocopy machine	- Layered modular architecture (LMA); loosely coupled layers spanning devices/networks and software/services/content. - Heterogeneous materiality: tangible (hardware/devices/networks) integrated with intangible (software, services, content) – a range of smart devices: e.g. iPhone, iPad, Samsung Galaxy series
Organizational design focus	- Refining physical attributes and form for a distinct functional purpose within well-defined design constraints - Emphasis on aesthetics and structural configuration within product parameters towards finalized design output once design is done	- Orchestrating diverse components across layers; accommodating generativity Concerned with continual recombination of digital components in distributed digital ecosystem - Produce evolving meanings and value through ecosystem participation and evolving social and technical demands; reprogramming and adaption are enabled through co-creation in digital ecosystem
Design management implication	- Emphasis on managing within defined product parameters (e.g., aesthetics, structural configuration, functionality) - For the completion of a final design output, controlling and governance -oriented design languages used	- Emphasis on managing generativity and ecosystem coordination; new skills to cultivate generative capacity and govern evolving sociomaterial practices. - Ongoing/open-ended design and generative capacity support continuous adaptation and management of evolving, incomplete artifacts (e.g., to design).

extensive datasets drawn from digital platforms (Yoo et al., 2024). In this context, GenAI can amplify generativity by accelerating knowledge creation and creative problem solving through algorithmic generation and recombination (Hutter et al., 2026; Sreenivasan & Suresh, 2024).

Design management research has therefore examined how AI can be integrated into innovation processes such as design thinking (DT) (Cai et al., 2026; Sreenivasan & Suresh, 2024; Verganti et al., 2020). A recurring theme is how to manage algorithmic, AI-driven innovation alongside heuristic, human-centered approaches so that AI-augmented processes still deliver solutions grounded in human needs and values (Cai et al., 2026; Sreenivasan & Suresh, 2024; Yoo et al., 2024).

GenAI is now used widely across design fields. GenAI tools can support data-driven design activities—such as user research, sensemaking, and rapid prototyping—by expanding the space of alternatives and accelerating some analytical and generative tasks (Sreenivasan & Suresh, 2024). Used well, these capabilities can help teams develop more human-centered solutions (Sreenivasan & Suresh, 2024; Verganti et al., 2020).

However, the literature also highlights limitations and practical concerns (Cai et al., 2026; Hutter et al., 2026; Sreenivasan & Suresh, 2024). GenAI-enabled design often relies on open and distributed innovation networks to improve LLM performance, which increases the need for human-led governance when managing AI-powered, generative design work. For example, design professionals must safeguard data privacy and ensure transparency in AI-enabled user research (Sreenivasan & Suresh, 2024). Moreover, the volume of content produced in GenAI-augmented design can create cognitive overload for human decision-makers, and efficiency-first convergence can reduce engagement with human expertise—potentially increasing homogenization in creativity and outcomes (Hutter et al., 2026; Sreenivasan & Suresh, 2024).

Against the backdrop of early optimism about open and enabling digital ecosystems, Yoo et al. (2010) argued that LMA can support digital innovation by enabling distributed actors to generate value at each layer and recombine digital components across layers through a largely self-organizing logic—what they describe as generativity. However, subsequent research has highlighted limitations and externalities that have become more salient in AI-driven digital innovation, including crowding, privacy risks, diminished user experience, and accountability challenges. In parallel, design management scholars have raised concerns about GenAI-enabled design practices that rely on open data without sufficient human-

centered attention to users and social consequences (Cai et al., 2026; Hutter et al., 2026; Sreenivasan & Suresh, 2024) (summarized in [Table 2](#)).

Consequently, scholars in both design and digital innovation management call for a more balanced approach to AI-powered digital innovation that combines enabling, generative design languages with appropriate control and governance (Cai et al., 2026; Yoo et al., 2024) ([Figure 6](#)). Duality perspectives explain this balance as an interdependence between stability (“control”) and flexibility (“generativity”), rather than a choice between opposites (Eaton et al., 2011; Farjoun, 2010). In highly generative digital ecosystems, insufficient control can create chaos and undermine value capture; Eaton et al. (2011) illustrate this tension by contrasting more closed (Apple) and more open (Google) ecosystem models. From a sociotechnical systems perspective, Yoo et al. (2024) similarly argue for strengthening governance in AI-powered ecosystems — for example, by updating policies and regulations for digital services and data privacy (e.g., GDPR) and by designing platforms that can both enable participation and enforce safeguards (e.g., privacy-preserving technologies of Apple). At the same time, they emphasize interdisciplinary collaboration and ongoing attention to the interplay between social agencies (stakeholders) and material agencies (technologies and organizations) in managing evolving digital materiality. Design management research also argues for balanced organizational strategies at the technical-system level, especially as GenAI makes design practices more open and scalable. Achieving productive AI–design synergy requires dedicated human expertise to filter and govern low-quality, unethical, or non-empathetic outputs produced in GenAI-augmented workflows—because such outputs can disrupt human-centered design, overload collective decision-making, and contribute to homogenized solutions (Cai et al., 2026; Hutter et al., 2026; Sreenivasan & Suresh, 2024). In the built-environment sector, for example, complex architectural and construction projects depend on effective risk management under uncertainty. As these projects increasingly incorporate AI-powered approaches (including BIM-enabled analytics), additional human expertise remains essential to address unpredictability and ensure accountable decisions in complex design settings (Hriday & Rehman, 2025).

Table 2. Key limitations and concerns in generative design in the era of AI

Level	Concerns/Limitations in the application of AI	References
Technical system design level (e.g. design research, prototyping, design thinking (DT) etc.)	• Limited understanding of real user needs, requiring dedicated human expertise to sustain human-centered design—for example, risks of non-empathetic outputs, data privacy challenges in AI-led user research, and weak grounding in lived user contexts. • Excessive reliance on efficiency-oriented AI tools without strategic guidance can weaken human-centeredness—for example, cognitive overload in filtering and evaluating outputs, challenges in collective decision-making, and continual upskilling required to maintain human expertise as AI advances. • Constraining human creativity and introducing cognitive bias when design work becomes overly dependent on AI-led processes.	Sreenivasan & Suresh, 2024 Cai et al., 2026 Hutter et al., 2026
Sociotechnical system level - generative designing in AI-powered institutional and structural system design	• Organizational fit and transformation needed to implement AI-driven design effectively, for example, where and how AI-enabled design should be introduced in real organizational contexts. • Accountability for AI-generated design outcomes. • Balancing design problem solving and knowledge creation between algorithmic (AI-led) approaches and heuristic human expertise (including decision-making practices and skill development).	Verganti et al. (2020).
	• Homogenization of behaviors in human expertise and of digital artifact design outcomes • Ethical concerns on data collection and management – e.g. overcrowding, gatekeeping, diminished user experience, and data privacy concern • Emerging uncertainties in social and technical system framework shaped and transformed by AI related technologies	Yoo et al. (2024)

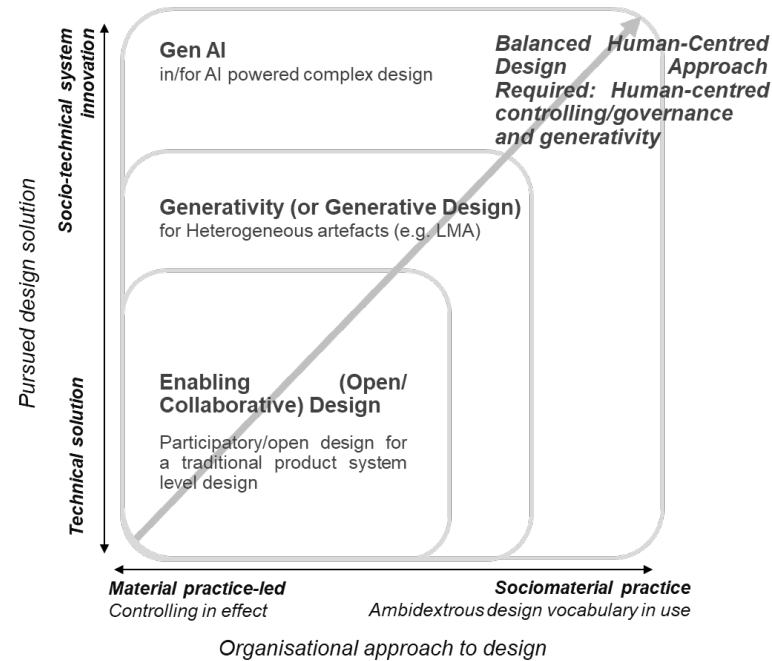


Figure 6 The conceptual framework of organizational approach to managing design by systems-level of design solutions

4. Concluding Remark

This paper examines how conceptions of design—and the organizational design languages used to coordinate and manage it—are being reshaped by AI-enabled digital innovation. Using a sociomaterial lens, it clarifies generative design by tracing how design languages evolve alongside technological change and growing sociotechnical complexity. Drawing on cases from Xerox PARC, where collaborative prototyping revealed design as sociomaterial work, and Frank O. Gehry’s projects, where technology-mediated collaboration and a shared vision enabled generative form-giving, the review shows a broad shift from control- and governance-centered approaches toward more enabling and generative forms of organizing.

Building on this synthesis, the paper connects generative design to the governance of digital materiality, characterized by heterogeneity, incompleteness, and continual reconfiguration, and uses layered modular architecture (LMA) to explain how generativity spreads across digital ecosystems. It also identifies a central tension: although openness can expand innovation opportunities, it can also increase risk and negative externalities, especially in AI-powered settings. Addressing this tension requires ambidextrous design management that supports generativity while applying nuanced, human-centered controls—such as governance mechanisms, regulatory oversight, and interdisciplinary collaboration—to guide design toward accountable and ethically defensible outcomes.

For scholarship, the review provides a conceptual basis for reassessing design and design management in AI-intensive organizational settings by connecting dispersed theories of sociomateriality in design and digital innovation management. For practice, it outlines key implications, including the limitations and risks that can arise when AI is adopted in sociomaterial domains such as design. Managing generative design therefore requires broader institutional and structural change, including innovation policy and organizational arrangements suited to complex product and service design projects.

By foregrounding the heterogeneous and rapidly evolving dynamics of AI-mediated sociotechnical systems, the paper supports more deliberate, human-centered managerial strategies and organizational designs.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author(s) used Paperpal and CoPilot embedded in MS Word to enhance the grammar and improve the manuscript's comprehension and fluency. The author did not employ any explicit prompts on generative AI to create new content or sections in the draft. After using this tool/service, the author reviewed and edited the content as needed and take(s) full responsibility for the content of the published article as the sole author

CRediT Authorship Contribution Statement

Hyunwook Hwangbo: Conceptualization, Methodology / Study design, Writing – original draft, Supervision, Project administration, Funding acquisition, Conceptualization, Methodology / Study design, Software, Formal analysis, Data curation, Writing – original draft, Writing – review and editing, Visualization, Supervision, Conceptualization, Supervision, Conceptualization, Supervision, Conceptualization, Supervision.



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