Co-evolution of Generative AI and Design Creativity: Mechanism Reconstruction from Auxiliary Tool to Creative Partner

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Abstract: Generative artificial intelligence is driving a profound transformation of design creativity from 'instrumental assistance' to 'collaborative co-creation with partners.' Focusing on human-machine co-evolution as the core perspective, this paper systematically reviews the evolution of the role positioning of generative AI in the creative design process, analyzes the quality differences and power dynamics of human-machine interaction under different collaboration modes, and proposes a human-machine creative collaboration mechanism model encompassing three dimensions: cognitive collaboration, process integration, and interactive feedback. Furthermore, it explores response strategies for ethical risks and educational challenges encountered during collaboration, such as algorithm transparency mechanisms and the transformation of design education paradigms. The study shows that the evolution of generative AI into a creative partner is not a one-way process driven solely by technology, but rather the result of bidirectional construction and co-evolution between humans and technology through continuous practical interaction. Its essence is a fundamental reshaping of the power relationship between 'humans' and 'machines' in creative production.

Keywords: Generative Artificial Intelligence; Design Creativity; Human-Machine Collaboration; Co-Evolution; Creative Partner

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1.Introduction

The rapid development of generative artificial intelligence is redefining the boundaries of design. From Stable Diffusion to Midjourney, from DALL·E to various large language models, AI systems have gradually evolved from 'tools for executing instructions' into collaborators capable of autonomously generating creative content and participating in design decisions. This transformation raises a fundamental theoretical question: What kind of relationship exists between generative AI and design creativity? Is it merely an efficiency tool, or is it becoming a genuine 'creative partner'?

Current academic discussions exhibit a notable trend: research perspectives are shifting from instrumental inquiries into 'whether AI can assist design' to relational reconstructions of 'how AI can co-create with designers'. From interactive interface design to experimental evaluation methods, from conceptual framework construction to empirical case analysis, research in the human-AI co-creation field has rapidly accumulated rich theoretical achievements and empirical materials between 2025 and 2026. However, a deeper question remains to be systematically addressed: What are the underlying collaborative mechanisms of the role evolution from 'tool' to 'partner'? What logic does this evolutionary process follow? This paper attempts to construct an integrative analytical framework based on inquiry into this core question.

2.From Tool to Partner: The Evolution of Human-Machine Role Positioning in Design Creativity

2.1 Instrumental Stage: AI as an Efficiency Enhancer

In the early stage of generative AI development, the role of AI in the design field is primarily defined by a 'tool logic'—where humans issue instructions and AI executes and outputs. In this model, the relationship between designers and AI exhibits a clear one-way dynamic: designers are the sole source of creativity and ultimate decision-makers, while AI functions as an efficient but passive execution terminal. As relevant research points out,

most current creative AI tools still operate on the logic of 'linear executors,' creating a fundamental tension with the inherently non-linear, iterative, and ambiguous nature of human creative activities.

The value of the instrumental stage is undeniable. AI significantly reduces the time cost from concept to sketch, enabling designers to conduct extensive visual exploration and solution iterations at extremely low marginal costs. However, this 'human-gives-instructions-AI-generates-images' model also has notable limitations: it does not touch the intrinsic mechanisms of creative generation but merely alters the efficiency of visual presentation. Designers remain the sole source of creativity, and AI stays positioned as a 'faster brush.

2.2 Collaborative Stage: AI as an Inspirational Engine

As multimodal generation capabilities improve and interaction methods are optimized, AI is beginning to move upstream into the creative process. It is no longer merely executing drawing instructions but can generate diverse visual possibilities based on vague concepts provided by designers, thereby inspiring new ideas. The core change in this phase is that AI transitions from 'outputting images' to 'outputting possibilities.' In systematic terms, AI's function expands from 'executing solutions' to 'generating solution spaces.

Scholars have pointed out that generative AI accelerates design space exploration and multimodal prototyping in industrial design, bringing new efficiency and possibilities to early conceptualization and cross-medium expression. Notably, generative AI can significantly enhance creative performance by alleviating the professional knowledge fixation designers face during the ideation stage. For novice designers, AI's value primarily lies in 'breaking the ice'—helping them quickly overcome the psychological barrier to starting creativity. For experienced designers, AI's value is more focused on 'breaking boundaries'—assisting them in transcending the limitations of existing cognitive frameworks and expanding the boundaries of creativity.

2.3 Partnership Stage: AI as a Co-Creator and Collaborator

Currently, human-AI co-creation research is entering a more challenging phase—viewing AI as a true 'co-creative partner.' This positioning transcends the categories of 'tool' and 'assistant,' implying that AI is granted the power to proactively generate, evaluate, and even adjust the direction within the creative process. In the partnership stage, the relationship between humans and AI is no longer one-way command-execution but rather a two-way negotiation-iteration-co-evolution.

A randomized controlled experiment involving 486 participants revealed differential impacts of various collaboration modes on creative outcomes: the model-dominated mode (AI independently rewriting creativity) significantly improved creative quality but reduced diversity and users' perceived creative ownership; in contrast, the reflective human-dominated mode (AI prompting designers' deep thinking through questions or suggestions) enhanced creative quality while maintaining diversity and ownership perception. This finding holds important theoretical significance: it indicates that AI's 'partnership' does not simply mean having AI do more, but rather having AI intervene in human cognitive processes in an appropriate way—not replacing human judgment, but stimulating human thinking. The study further suggests that interactions with generative AI should be designed as 'reflective thinking partners,' enabling them to complement human strengths and enhance the creative process. This phrase succinctly captures the essence of a 'partner': it is neither a passive executor nor an active replacement, but an entity capable of engaging in cognitive dialogue with humans and inspiring reflection.

3.Mechanism Reconstruction of Human-Machine Creative Collaboration: From the Perspective of Role Evolution

3.1 Cognitive Synergy Mechanism: From Unidirectional Mapping to Bidirectional Dialogue

The cognitive pattern of the instrumental phase can be summarized as 'unidirectional mapping': designer's intent → AI-generated outcome. This is a linear, one-time information transfer. Upon entering the collaborative phase, the cognitive pattern evolves into 'iterative feedback': designer proposes concepts → AI generates multiple possibilities

→ designer selects and reworks → AI regenerates based on feedback. However, the true partnership phase demands further advancement—entering the 'bidirectional dialogue' cognitive pattern.

Bidirectional dialogue' refers to the process where humans and AI not only exchange information but also co-construct meaning during creativity. AI is no longer an 'empty container' waiting for human commands; instead, it becomes an entity that can proactively raise questions, point out contradictions, and suggest directions. Establishing such a dialogic relationship requires AI to possess the ability to understand human creative intent, and it also requires human designers to learn 'to dialogue with AI'—a new language distinct from traditional design expression. Prompt engineering essentially embodies this 'dialogic language' in its embryonic form.

Some scholars have proposed a collaborative creative design framework encompassing three core dimensions: agency (balance of autonomy and control between humans and AI), interaction dynamics (evolution of relationships among collaborators and with the creative product), and communication (information exchange mechanisms between humans and machines). This framework reveals the inherent structure of human-AI collaboration at a theoretical level: cognitive collaboration is not a simple input-output relationship but a dynamic process unfolding around the three dimensions of 'power distribution—relationship evolution—information flow'.

3.2 Process Integration Mechanism: From Linear Relay to Circular Weaving

The creative process in the instrumental phase follows a 'relay model': humans handle idea generation, while AI handles execution and output. This is a linear, phased division of labor. In the collaborative phase, it evolves into an 'iterative loop': generate ideas → produce → evaluate → regenerate ideas → re-produce. In the partnership phase, the process integration further advances to 'circular weaving'—human and machine activities no longer follow a 'who-first-who-next' sequence but interweave and serve as prerequisites for each other.

A more structured framework divides human-AI co-creation into two stages: In the first stage (AI seeding ideas), AI rapidly generates creative concepts of known types, establishing the foundational 'soil' for creativity. In the second stage (human-enhanced ideation), humans use AI-generated content to engage in unstructured creative generation, refining initial ideas and introducing 'content gains/losses' that go beyond traditional augmentation frameworks. This two-stage model reveals the process logic of human-AI co-creation: AI is responsible for 'divergence' to expand the space of possibilities, while humans are responsible for 'convergence' to 赋予意义和方向 (endow with meaning and direction). The alternating cycle of these two stages forms a complete closed loop for creative generation.

Another study, drawing from industrial design practice, has constructed a generative AI-driven framework spanning four core phases: requirement confirmation, concept generation, concept evaluation, and 3D modeling. Through a traceable cross-phase artifact flow of 'structured prompts → candidate concepts → evaluation outputs → engineering problem lists', it supports continuous constraint transmission from requirements to engineering. The value of this framework lies in its extension of human-AI co-creation from a 'soft' process of inspiration generation to 'hard' requirements of engineering constraints, providing methodological support for the full-process integration of human-machine collaboration from early concepts to final products.

3.3 Interactive Feedback Mechanism: From Unidirectional Output to Reflective Dialogue

Interactive feedback serves as a key metric for measuring the depth of human-machine collaboration. During the instrumental phase, feedback remains unidirectional: AI only receives human instructions without generating responses. The collaborative phase introduces initial bidirectional feedback, allowing AI to adjust outputs based on human evaluations. However, the true partnership phase demands that AI possess "reflective feedback" capabilities—not only adjusting outputs according to instructions but also proactively identifying blind spots, contradictions, or risks in creative processes, and appropriately raising questions or providing suggestions to humans.

Experimental studies have revealed an intriguing paradox: While model-driven AI interaction patterns enhance creative quality, they significantly diminish users 'sense of creative ownership. This suggests that when AI

proactively revises human-generated ideas, designers may feel "this isn't my work." Conversely, reflective human-led modes (where AI prompts designers to reflect through questioning) improve quality while preserving creative agency. These findings offer crucial insights for designing interactive feedback mechanisms: effective AI feedback should not be "I'll revise it for you," but rather "Have you considered this possibility?" AI's "humility" may actually foster genuine co-creation more effectively than its "assertive" approach.

4.Challenges and Responses in Synergistic Evolution

4.1 Creative Power Dynamics and Designer Autonomy

As generative AI becomes more deeply involved in creative decision-making, a fundamental risk emerges: designers' creative autonomy is being quietly eroded. An experimental co-creation study spanning three months with three designers found a significant 'power dynamic' between large language models and designers, where designers readily lose their creative autonomy during this process. The study further notes that reclaiming creative autonomy requires designers to engage in introspection about their own creative processes, develop a systematic understanding of the structures of the emerging technologies involved, and consciously adjust the dynamics of the human-technology relationship.

The challenge of creative autonomy is not a technical issue but a core concern in human-AI relationship design. As highlighted by a theoretical study, current AI tools, which operate on a 'linear executor' logic, are fundamentally at odds with the non-linear, iterative, and ambiguous nature of human creativity. This suggests that to truly evolve from 'tools' to 'partners,' we cannot rely solely on enhanced technical capabilities; instead, we need to redesign the interaction interfaces between humans and AI—enabling AI to learn to 'ask questions' before 'providing answers.

4.2 The Dilemma of Algorithmic Bias and Embedded Values

The widespread application of generative AI in the design field has also brought about subtle but profound ethical risks. A study published in a Nature subjournal points out that biases in AI systems not only come from training datasets but more so from the values and assumptions of programmers—these values are unconsciously embedded into the operational logic of AI through code, known as 'secondary arbitrariness'. This means that AI-generated 'creativity' is never neutral; it carries the cultural background, aesthetic preferences, and value judgments of its developers. The study further proposes institutional designs such as 'algorithm designer reflexivity statements' and 'AI stance declarations' to enhance the transparency and accountability of AI systems.

Additionally, research has warned of the risk of creative homogenization posed by 'general aesthetic alignment'—when AI models are trained to prioritize outputting 'beautiful' content, they actually narrow the possibilities of artistic expression and exclude low-quality or negative images that do not conform to mainstream aesthetics. The implication for the design field is profound: if designers rely on AI-generated content without critical evaluation, design creativity faces an unprecedented risk—homogenized mediocrity replacing diverse innovation.

4.3 The Pressure for Paradigm Shift in Design Education

The deepening of human-machine co-creation is forcing a fundamental restructuring of design education systems. Currently, many universities in China have already begun proactive explorations. Some universities will start offering the course 'Generative Artificial Intelligence (AIGC) Design Fundamentals' to freshmen from 2025, establishing a dynamic updating mechanism with over 30% revision each semester to ensure cutting-edge tools and technologies enter classrooms promptly. In terms of curriculum system building, some institutions are advancing a three-tiered curriculum cluster structure of 'Basic Literacy - Professional Core - Cross-Disciplinary Expansion', and taking the disruptive impact of AIGC technology on design education as a key topic for discussion.

On a more macro level, scholars are systematically elaborating on the evolution trend of design education from 'technology-driven' to 'value co-creation', emphasizing that talent cultivation in the Design 5.0 era needs to focus on human-machine collaboration and social responsibility, requiring systematic restructuring of curriculum systems,

teaching methods, and evaluation mechanisms. These practices and discussions collectively point to a core proposition: in an era where generative AI is increasingly becoming a creative partner, design education needs to cultivate not 'people who can use AI', but 'people who can co-create with AI'—that is, designers who maintain a leading position in human-machine collaboration, critically examine AI outputs, and consciously guide values.

5.Conclusion

The relationship between generative AI and design creativity is undergoing a profound historical transformation. While the evolution from tool to collaborative partner appears driven by technological advancements, it fundamentally represents a paradigm shift in human-machine interactions. The three-dimensional collaborative framework proposed in this paper—cognitive synergy, process integration, and interactive feedback—unveils the underlying logic: the extent of technological empowerment ultimately depends on whether humans and AI can establish truly "dialogical" relationships.

It must be emphasized that AI becoming a "creative partner" does not imply the relinquishment of designers' authority or the erosion of professional boundaries. On the contrary, this transformation imposes higher demands on designers—not only mastering technical tools but also cultivating cognitive leadership and value judgment in human-machine interactions. In this sense, the ultimate goal of human-machine co-creation is not to make AI "more human-like," but rather to enable both parties to leverage their unique strengths and jointly achieve creative outcomes beyond individual capabilities. Future research should focus on empirical exploration of "optimal collaboration models" across different design tasks and comparative analysis of human-machine co-creation mechanisms in cross-cultural contexts, thereby advancing theoretical depth and practical implementation in this field.

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