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Perspective

Designing Beyond the Tool: Technology, Creativity and the New Boundaries of Design

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Design has always evolved through its tools. Drawing instruments changed representation; industrial production transformed form, function, and scale; and digital modelling expanded what could be imagined and manufactured. Today, artificial intelligence, digital twins, immersive environments, data-intensive systems, and computational fabrication are transforming design. The shift is not simply about faster tools. These technologies influence how problems are framed, alternatives generated, experiences communicated, decisions made, and consequences evaluated.

This changing condition defines the intellectual space of *TechDesign*. Design is moving beyond isolated artefacts and interfaces towards complex sociotechnical systems in which people, technologies, organisations, environments, and values interact. Technologies are often developed with limited design involvement, leaving human experience and social consequences to be addressed only after technical decisions have been made. Designers should participate from the beginning: defining problems, questioning assumptions, deciding what should be automated, and anticipating consequences. Technology can expand the boundaries of design, but design must also shape its purposes, values, and limits.

Research on design creativity offers a useful starting point. Goldschmidt [1] identified artificial intelligence and neurocognitive research as forces that changed how creativity could be studied, moving the field beyond anecdotal accounts and simplified models of divergent thinking. Her earlier work showed that designers move repeatedly between divergent and convergent modes of thought throughout idea generation [2]. This perspective is particularly relevant in the age of generative artificial intelligence. Computational systems can rapidly produce images, texts, interfaces, forms, and scenarios, enlarging the space of alternatives. Yet abundance is not the same as creativity, and generation is not the same as design. Design requires judgement: understanding context, recognising significance, interpreting evidence, and accepting responsibility. A system may generate plausible proposals, but the designer must still determine which are meaningful and worth developing.

Design creativity is not confined to internal mental processes. Designers think through sketches, models, materials, prototypes, conversations, and bodily interaction. Ideas often emerge through making. Tools influence what designers perceive, which questions they formulate, and which possibilities they can externalise. Dalsgaard [3] describes design tools as instruments of inquiry. Designing beyond the tool means recognising that tools shape thought while refusing to let their capabilities determine the aims or quality of design.

Creative intuition and the designer's own judgement are not sufficient to establish design quality. Contemporary design problems increasingly require collaboration among designers, engineers, human factors specialists, communication specialists, domain experts, and people affected by systems. No single discipline can fully anticipate the consequences of a design decision.

Rigorous evaluation must therefore be integrated throughout the design process. It may draw on technical, experiential, and contextual evidence, according to the objectives and risks of the system. Functional performance, human experience, cultural meaning, and safety require complementary forms of assessment. Rigour should not be confused with quantification alone, nor should subjective qualities be exempted from critical examination. Evaluation criteria should be explicit, methods appropriate, and conclusions supported by triangulated evidence. This position is consistent with ISO 9241-210 [4], which places human-centred design activities, including iterative evaluation, throughout the lifecycle of interactive systems.

One important frontier is the integration of visual design within a broader multisensory understanding of experience. Visual thinking remains fundamental. Sketches, renderings, typography, colour, images, and interfaces are powerful means of exploration and expression. The limitation arises when what can be seen is treated as the whole of experience, a tendency reinforced by the dominance of screens.

Human experience integrates sight with hearing, touch, smell, movement, proprioception, temperature, and spatial perception. Products are encountered through appearance, weight, texture, resistance, sound, and responsiveness; spaces through light, acoustics, material surfaces, air, smell, and bodily movement. Interfaces may communicate through vibration, spatial audio, gesture, or force feedback. Multisensory design therefore requires designers to intentionally shape different sensory qualities rather than to focus exclusively on appearance [5,6].

The goal is not to accumulate stimuli. Additional sensory information may create distraction, overload, discomfort, or contradiction. The challenge is to decide which sensory channel should communicate what, under which conditions, and for which users. When aligned with perceptual abilities and task demands, multisensory approaches can support richer and more inclusive experiences. Technology creates sensory possibilities; design must transform them into coherent experiences.

A second frontier concerns complex sociotechnical and safety-critical systems. Healthcare, transport, aviation, energy, emergency management, industrial control, and autonomous systems involve interactions among people, automation, procedures, organisations, and environments. Failure may result in disruption, injury, environmental damage, or loss of life. Norman and Stappers [7] argue that such problems cannot be addressed through approaches developed for isolated products because implementation is shaped by organisational, cultural, political, and economic forces.

Design quality in these contexts must address risk, reliability, situation awareness, workload, foreseeable use errors, recovery, and safety. Designers should enter complex projects early, working with operators, engineers, ergonomists, safety specialists, and domain experts. Their contribution includes making system states

and risks perceptible, reducing ambiguity, supporting decisions, and preparing for failures. Research on safety-critical control panels demonstrates the importance of involving expert users and integrating professional knowledge [8]. Prototypes, simulations, digital twins, and immersive environments can support this process, but their value depends on credible scenarios, appropriate measures, and technical verification. In these settings, good design is part of system safety.

Communication is equally constitutive of technological innovation. Visual language, sound, narrative, interaction, and identity influence how technologies are interpreted, trusted, adopted, and contested. Communication design also shapes the identities, narratives, and strategic relationships through which technologies acquire cultural and organisational meaning. As communication becomes generative and responsive, designers must address authorship, authenticity, cultural specificity, and visual homogenisation. Their task is to give complex technologies forms that people can understand, use, and question.

Data-driven methods can deepen understanding, but datasets reflect decisions about what is collected, categorised, represented, and excluded. Behavioural records may reveal patterns while obscuring motives, emotions, and cultural meanings. Human-centred artificial intelligence must combine computational capability with meaningful human control and opportunities for intervention [9]. Human-centred design is not achieved by collecting more data about people. It requires respect for autonomy, recognition of diversity, and the involvement of those affected by design decisions.

The expansion of design into systems also requires environmental and social responsibility. Design for sustainability has progressed from individual products towards services, communities, and sociotechnical transitions [10]. Durability, repairability, maintenance, resource use, accessibility, and systemic effects should be considered from the outset. Sustainability can also enable circular practices and alternative forms of value.

TechDesign should provide a platform for research in which technology is critically transformed through design knowledge, interdisciplinary collaboration, and evidence about human experience. Novelty alone is insufficient. A new algorithm accompanied by an interface, or an industrial case without transferable knowledge, does not automatically constitute a contribution to design. Authors should demonstrate what their work adds to design practice, evaluation, communication, safety, sustainability, or the understanding of human experience.

Designing beyond the tool does not mean rejecting technology. It means moving beyond fascination with what a tool can produce towards critical consideration of what should be created, how its quality can be demonstrated, how it will be experienced, whose lives it will affect, and what futures it will help to sustain. These are the new boundaries of design. They are also the boundaries that *TechDesign* invites its contributors to explore.

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