



Journal of
Mechanical
Design

Guest Editorial

Special Issue: The Role of Design Artifacts in Design

Introduction

Design artifacts, including sketches, prototypes, simulations, and computer-aided design (CAD) models, are critical to innovation. Artifacts are vehicles for information transmission and storage and enable designers to communicate across cognitive and social boundaries. Traditionally, the interaction between design artifacts and innovation processes has been studied within the context of geographically co-located teams. However, the COVID-19 pandemic has upended how traditional design occurs, and the use of digital and physical design artifacts by distributed, hybrid, and co-located teams has changed significantly. While the nature of work has changed, so too has the technology available to designers. For example, with significant advances in cloud computing, collaborative CAD platforms are becoming increasingly common throughout design processes, allowing teams of designers to create, edit, or augment CAD components and assemblies. Yet, virtual platforms often stymie designers' abilities to pick up on non-verbal cues from their teammates, and the effect of these digital collaborative platforms on team dynamics and performance needs to be critically assessed. The age of artificial intelligence (AI) has also brought about a significant paradigm shift in our discussions and conceptualizations of design artifacts. AI-enabled platforms, like Chat-GPT or Mid-Journey, can, e.g., serve as critical tools for designers, allowing design teams to rapidly engage with both far and near design stimuli, create design specifications based on user data, or generate hundreds of design prompts to spark innovative ideas.

As we developed this special issue, our goal was to formulate a collection of articles that explored emerging topics in a more traditional area of design theory and methods research. The articles that comprise this collection fall into three primary categories: (1) enhanced communication via design artifacts, (2) technology-enabled design artifacts, and (3) collaborative design platforms that enable collective creation. Articles in the first category gravitate toward studies that explore the interaction between design artifacts and communicative actions and/or outcomes, investigating the role design artifacts play in communication, and developing guidelines for enhanced communicative efforts. Articles in the second category contribute new perspectives on the interactions between novel technologies and the design artifacts enabled by these technologies. The third category of articles explores the utility of multi-user platforms for collective creative; as it happens, all of the papers in this collection examine collaborative CAD platforms and the effect of these collaborative environments on fundamental design team processes and artifact generation.

While these articles contribute novel insights into the intersections between design artifacts and advanced technologies, we

highlight that many of these papers hinge on the actions, performance, or behaviors of the human designer. Much of this work explores the use of design artifacts as an extension of the designers themselves, a conduit through which designers make and translate meaning. We highlight that the interactions between designers and design artifacts remain poorly understood, and underscore this as a critical area for future work to explore, particularly in the context of advanced technologies, such as AI and collaborative design platforms. Importantly, the articles in this special issue make use of several novel methods or experimental approaches, a valuable contribution to the field in and of itself. The remainder of this Guest Editorial elaborates on the collections of research articles presented in this special issue.

Enhanced Communication Via Design Artifacts

The research articles on this theme generally focus on investigating the role of design artifacts and related communicative actions. Specifically, these works evaluate the effectiveness of various modalities of artifacts given particular communicative contexts. Importantly, these articles contribute critical insights that build our fundamental understanding of the characteristics of design artifacts that contribute to or detract from effective communication.

The article "If You Build It, Will They Understand? Considerations for Creating Shared Understanding Through Design Artifacts" by Krishnakumar, Letting, Soria Zurita, and Menold explores the role of design artifacts in design communication via mixed-methods study. While quantitative findings reveal that both low-fidelity prototypes and sketches foster similar levels of shared understanding between designers, qualitative results shed light on a more nuanced relationship between artifacts and shared understanding. Their findings inform our understanding of the factors that affect the ability of designers to successfully build shared understanding via design artifacts.

The article titled "Requirements, Objectives, Both or Neither: How to Formulate Complex Design Problems for Innovation Contests" by Vrolijk and Szajnfarter considers design problem statements as unique design artifacts that have a significant impact on the trajectories of innovation contests. Motivated by the challenges of communicating complex problems across disciplinary boundaries, as is often the case in innovation contests, the authors formulate an inductive model of problem formulation processes based on five distinct innovation contests. Their findings hold significant implications for both innovation contests and our understanding more broadly of problem formulation processes within design theory and methods.

Digital and Artificial Intelligence-Enabled Design Artifacts

The research articles in this theme generally explore the utility of intelligent tools or AI-enabled design artifacts to enhance designer ability or performance. Emergent findings from this theme inform our understanding of design artifacts in the age of AI and generative design, providing critical insights into the effects of intelligent platforms and tools on designer behavior.

The article “Using AI-Enabled Divergence and Convergence Patterns as a Quantitative Artifact in Design Education” by Chiu, Sim, Mun, and Silva, builds a novel AI-enabled visualization dashboard that provides design educators with critical insights into the progression of the class on the whole. Using natural language processing models, the authors visualize student and team progression through divergent and convergent design activities, providing instructors with a more holistic understanding of teams and enabling just-in-time intervention.

The article titled “The Influence of Digital Sketching Tools on Concept Novelty and Evolution” by Das, Huang, Xu, and Yang, characterizes the effect of novel digital design tools, specifically tablets, on design creativity, novelty, and concept evolution. Through a controlled study, the authors demonstrate that, as compared to paper and pencil, sketches created with tablets did not significantly differ in terms of concept novelty. More nuanced findings do suggest, however, that the use of the tablet may lead to more cases of consecutive concept evolution as compared to non-consecutive concept evolution.

The article titled “A Study on Generative Design Reasoning and Students’ Divergent and Convergent Thinking” by Brown, Goldstein, Clay, Demirel, Li, and Sha investigates how students engage with generative design software in an introductory graphics and design course. Through an in situ study of student designers, the authors investigated linkages between cognitive abilities and generative design understanding. Findings suggest that students approach generative design decision-making similarly to conventional decision-making, indicating that the challenges posed by new computational tools are comparable to those with traditional tools.

Collaborative Design Platforms That Enable Collective Creation

Articles in this theme specifically explore the utility and efficacy of collaborative design platforms, such as cloud-based CAD platforms. These articles provide critical insights into the effect of these digital collaborative environments on team dynamics and performance.

The article titled “Analysis of Collaborative Assembly in Multi-User Computer-Aided Design” by Cheng and Olechowski investigates the collaborative dynamics and overall performance of design teams leveraging cloud-based multi-user cloud platforms to design CAD assemblies. The article is motivated by the rapid advancements in cloud computing and collaborative CAD platforms that enable design teams to collaborate on part or assembly models in real-time. Their results reveal that design teams are able to more quickly create assembly models, as compared to single-users, but that single-users are more efficient on a person-to-person basis, due to communicative and collaborative overhead associated with teams.

The article titled “Designing Together: Exploring Collaborative Dynamics of Multi-Objective Design Problems in Virtual Environments” by Roy, Calpin, Cheng, Olechowski, Argüelles, Soria Zurita, and Menold explores the effect of virtual environments and collaborative cloud-based CAD platforms on the interaction dynamics of design dyads. Motivated by the rapid transition to hybrid work environments, first spurred by the COVID-19 Pandemic, the authors investigate the effect of collaborative virtual environments on the communicative patterns exchanged between design team members. Findings inform our understanding of how

designers may effectively leverage virtual technologies to more effectively collaborate.

The article “Comparing and Evaluating Human and Computationally Derived Representations of Non-Semantic Design Information” by Kwon and Goucher-Lambert compares human and computationally derived representations of 3D model parts across visual and functional similarity. The article is motivated by the significant advances in AI platforms and their increased use as team members, as opposed to merely tools. Results suggest that humans and AI may be more aligned in similarity ratings for low, as compared to high, similarity parts. Importantly, the authors found that both human and AI-derived relationships reflect concepts of “near” and “far” stimuli with respect to similarity. This article is particularly critical as we consider the role of AI as a more embedded member of design teams and explore the fundamental interactions between human and AI designers.

Future Directions for Research

The articles featured in this special issue contribute novel perspectives that shift our fundamental understanding of the role of artifacts, particularly in the digital age. We note that almost all the articles in this special issue specifically explore digital artifacts and the integration of advanced digital tools into design processes. While this was not an initial focus of the special issue, we highlight that it raises several critical questions for future work. We know from prior work in prototyping and modeling that physical building activities can be critical to the formation of accurate mental models [1–4], the identification of system errors [5–7], and the extraction of valuable user feedback [8,9]. Yet, as most of these articles focus on digital artifacts, platforms, and technologies, we wonder what critical aspects of design processes may be lost in a new digital age of design. What are the unique benefits of physical prototyping and how can we, as designers, use digital tools to elicit similar benefits? Are there certain activities or artifacts that must rely on physical real-world interactions to maintain the quality and/or rigor of the design process itself? Answering these questions will inform how we as design researchers begin to develop methods, tools, and interventions to support designers more effectively in a digital age.

Additionally, some of the articles in this special issue highlight the increasingly interdisciplinary nature of design teams. We highlight this as a particularly relevant area and context through which to explore the utility of design artifacts, as prior work has noted the ability of design artifacts to act as boundary objects [10,11], helping designers traverse boundaries and translate meaning. Language is a unique construct that shifts across disciplinary boundaries, and disciplinary discourse, or the unique vernacular of particular fields, can serve as a significant obstacle for interdisciplinary teams hoping to form a shared understanding. We argue that design artifacts will increasingly serve valuable roles within design teams and throughout design processes as objects and/or tasks that contribute to a shared understanding of the design process and/or concept itself. Future work is needed to understand the ways in which interdisciplinary teams interact with design artifacts, and how these artifacts may enable designers to effectively cross disciplinary boundaries.

Finally, we note that several articles in this special issue use design artifacts enabled or supported by AI. While we are still trying to understand the role of AI tools in design, and study AI-designer interaction, trends suggest that new generative AI technologies will be able to generate design artifacts at a rate and scale far surpassing anything we’ve seen before. How can this generative power be best harnessed for design? Will the speed of generation allow for faster iterations, and more efficient design? Will the massive amount of potential artifacts introduce too much noise to the process? What is missing from the design process when the designer no longer generates the artifact, rather focusing their efforts on specifying and evaluating it? Will the prominence of

AI tools push the design process even further from the physical and toward the digital realm? The advancement of our understanding of AI powered artifacts has the potential to not only deliver practical applied design impact but also reveal fundamental knowledge about what good design is and what good designers do.

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