Editorial

Computational making

Over the past few years, there has been growing interest in materials, material practices, and new production processes spanning different design activities and domains. 'Making', a keyword for these interests, has been moving center stage in design debates. One telling indication of this trend are remarks in the concluding panel of the 2014 Design Research Society Conference in Umeå, Sweden that declared 'making' central to design inquiry. 'Making' in that conference was closely linked to the new possibilities of digital fabrication. This coupling is not uncommon. Most studies of 'making' and 'makers' currently revolve around digital fabrication – its pragmatics and techno-social implications. However, such close links between making and digital production technologies are limiting.

To expand the understanding of making beyond its current bounds, to explore broader potentials for computational theories and techniques in making activity, and to investigate relations between making activity and design activity, we (editors), together with MIT doctoral student Dina El-Zanfaly, recently launched a research initiative on a topic we called *Computational Making*. To engage a wider community of researchers and practitioners in delineating this new area of research, we convened a workshop on Computational Making in July 2014 at the Sixth International Conference on Design Computing and Cognition (DCC'14) at the University College London. An interdisciplinary group of participants from the arts, architecture, design, information science, mathematics, and philosophy presented short position papers on the workshop theme. This Special Issue of *Design Studies* includes seven papers that grew out of ones initially presented at the workshop. They illustrate a variety of perspectives on the theme of Computational Making and the scope of issues and challenges raised by the topic. These papers, and others presented at the workshop, were developed in response to our initial framing of Computational Making as an area of inquiry. Our framing was based on broadly defined conceptions of both 'computation' and 'making', from which we proposed questions about how making and computation might come together, and how they might relate to design.

1 What is computational making?

On a conceptual level, we use 'making' as a keyword for action-centric, process-oriented attitudes toward the production and use of material things. Making might include the making of things – from drawing a picture on paper, to weaving a basket, to building an interface, to 3D printing a model, to machining and assembling engine parts, to constructing a building. Making might also expand beyond things to encompass other active, constructive processes, for example, making use, meaning, sense, and so on. Our construal of making follows recent developments in material culture studies, which our Special Issue aims to bring into dialog with design studies. In recent years, British anthropologist Tim Ingold has famously developed making as a new theoretical approach to the formation of things (Ingold, 2013), while American philosopher Beth Preston has advocated for extensions of this approach to the function of things (Preston, 2013: p. 189). In parallel with these developments, new technologies and production paradigms – for example, rapid prototyping and personal fabrication –

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have been engaging growing numbers of designers and users in the manipulation of physical things, instigating widespread interest in processes and technologies of making and their implications for design.

In the context of these developments, a systematic study into creative processes of generating and engaging with material things – what we term 'making activity' – is timely. We approach making activity as a process that is *time-based* (unfolding in real-time, in-the-moment), *dynamic* (changing), *improvisational* (dealing with uncertainty, ambiguity, and emergence), *contingent* (subject to chance and the unique), *situated* (within a social, cultural, physical environment), and *embodied* (engaging the (maker's) active body and sensori-motor capabilities). We also see the study of making activity as vitally concerned with the *things* made and their physical and material properties, as well as the *tools* and *technologies* employed.

The relationship between making activity and design activity is an open question that underlies our inquiry. Making could be construed as an extension or continuum from designing, as subsuming designing or vice versa, or otherwise. The papers in this Special Issue demonstrate this range of possibilities. Importantly though, our account of making contrasts in notable ways with some prominent accounts of design. Our account of making foregrounds the material and perceptual, as opposed to the immaterial and cognitive. We invoke making as a productive counterpoint to long epistemic traditions that have approached design as an abstract, intellectual enterprise with a concomitant emphasis on design 'thinking' and 'reasoning'. Herbert Simon's characterization of design as 'mental window shopping' (Simon, 2001: p. 164) or, venturing further back in history, Leon Battista Alberti's definition of design as the 'pre-ordering of the lines and angles conceived in the mind' (Alberti, 1986 [1755]: p. 2) are two seminal examples. However, design as an abstract enterprise separate from or prior to making (along with related dichotomies of thinking versus doing, mind versus matter, subject versus object, and so on) is a debatable notion, even in the most conceptual of fields. As the theoretical biochemist, Otto Rössler, observed and put into practice: 'essentially mathematics is nothing more than pottery […] it is always real things one manipulates' (Samuel, 2012: p. 52, p. 54).

Though our perspective on making runs counter to some views of design, it shares some common ground with practice studies of designing. For example, the Special Issue of *Design Studies* on Studying Design in Practice (*Design Studies*, *33*(6) 2012), foregrounded 'situatedness' and '*in vivo* actions' as key to describing how design happens in various practice settings. The papers in that Special Issue focused primarily on human actors, their cognitive processes and social interactions, as they engaged in designing. Such studies of design-in-action have also become the subject of a new field of study termed 'design anthropology' (Gunn & Donovan, 2012). Our Special Issue is concerned too with the dynamic activities of designing and making. However, we shift the focus from human actors to the *relationships* of their actions and experiences with the properties and agencies of the materials they work with, the things they generate and use, and the tools (human or machine) they employ. This focus is in keeping with recent developments in cognitive studies and the philosophy of mind that emphasize the embodied nature of cognition (Clark, 1997; Damasio, 1999; Johnson, 2007; Shapiro, 2011) and the extendedness of the mind in the physical world (Malafouris, 2013; Robinson, 2013). It is also continuous with discussions of material agency and engagement, as they have unfolded recently in anthropology