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Towards a Socio-material Framework for Systems in Design

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Abstract

This working paper addresses the ambiguity around systems in design by developing a tentative socio-material framework for categorising systems articulation within design. It suggests that there is not a single systems design approach, but that there are multiple articulations that are divided as to “how to know systems” and “what systems are composed of”. The paper suggests that there needs to be much more clarity and specificity about what kind of system is assumed or intended to be designed. It identifies that visualisation is the dominant mode of engaging with systems, which reinforces the notion of systems as knowable. In contrast, there are other approaches to systems that suggest they can be transformed directly. Finally, the paper argues that systems thinking is changing design, becoming a knowledge practice and knowledge broker, which has distanced design from its material impacts on the world.

Introduction

We often talk about systems when we want to describe things that are complex and have interconnected elements. The major problems of the 21st century, such as climate change and the carbon economy, have often been described as "wicked problems" (Rittel & Webber, 1973) because they are systemic and hard to tackle by established means, requiring fresh approaches to bring about change — something that design is being used for increasingly (Buchanan, 1992). Yet, how exactly does the design discipline engage with systems? Design theorist Richard Buchanan argues that there has been a historic shift in design towards complexity that has moved away from creating 'symbols' and 'artefacts' towards 'interactions' and 'systems', which he coins as the "four orders of design" (Buchanan, 2001). Systems in design thus represent a move away from the atomised user of design objects towards engaging with the complex structures that organise the world. Buchanan provides a loose definition of systems as an all-encompassing totality that includes physical things and people, as well as the values, principles and conditions of how they are organised. Yet, he suggests there remains a "deep ambiguity" (2019) about what systems mean in design. Indeed, when I discussed this with design colleagues, many suggested that they were working with 'systems', but did not use the term because it was confusing and vague. Buchanan suggests that designers often use the word "system" as an equivalent to other terms such as "structure, form, functionality, organization" (2019, p. 86) to indicate that design is part of a wider context. A variety of systems design approaches have emerged across education and academia, as well as commercial and industrial design that are often unrecognisable across design approaches. As an example, when Dubois & Dubois (2006) talk about carrying out social design using a "holistic whole-system" approach (Bertalanffy, 1968), they are describing the organisational restructuring of a business, something that may not be recognisable to many designers.

This study tries to address the ambiguity around systems by providing a historical context, a review of the contemporary design literature, as well as offering a tentative socio-material framework for mapping systems articulations. The paper consists of five sections. The first introduces the framework of the study. The second presents a historical overview of systems theories. The third is an overview of design and contemporary systems ideas in the academic design literature. The fourth maps design articulations within the framework of this study, while the fifth section offers a discussion of the framework. In summary the paper's conclusions are:

1. The multiple notions of systems are incommensurable

There is a sharp divide between structuralist approaches that focus on centralised 'whole' systems that can be analysed and optimised by an observer, versus post-structuralist notions where systems are messy and unknowable, and designers have to design from within them. There is also a parallel split between dualistic approaches that invoke 'hard' mechanical systems and 'soft' systems of people, versus a socio-material approach focused on machine/nature hybrids. The ambiguity about systems in design would be much reduced by more clarity and specificity as to the nature of the system assumed or intended by the designer.

2. Visualisation is the dominant method for engaging with systems

From the early soft systems approaches of 'rich pictures', it is via visualisation that design has engaged with systems. Yet, there is little recognition of socio-material approaches where design can enact and intervene in systems directly, without the intermediary step of visualisation.

3. Systems thinking is changing the nature of design

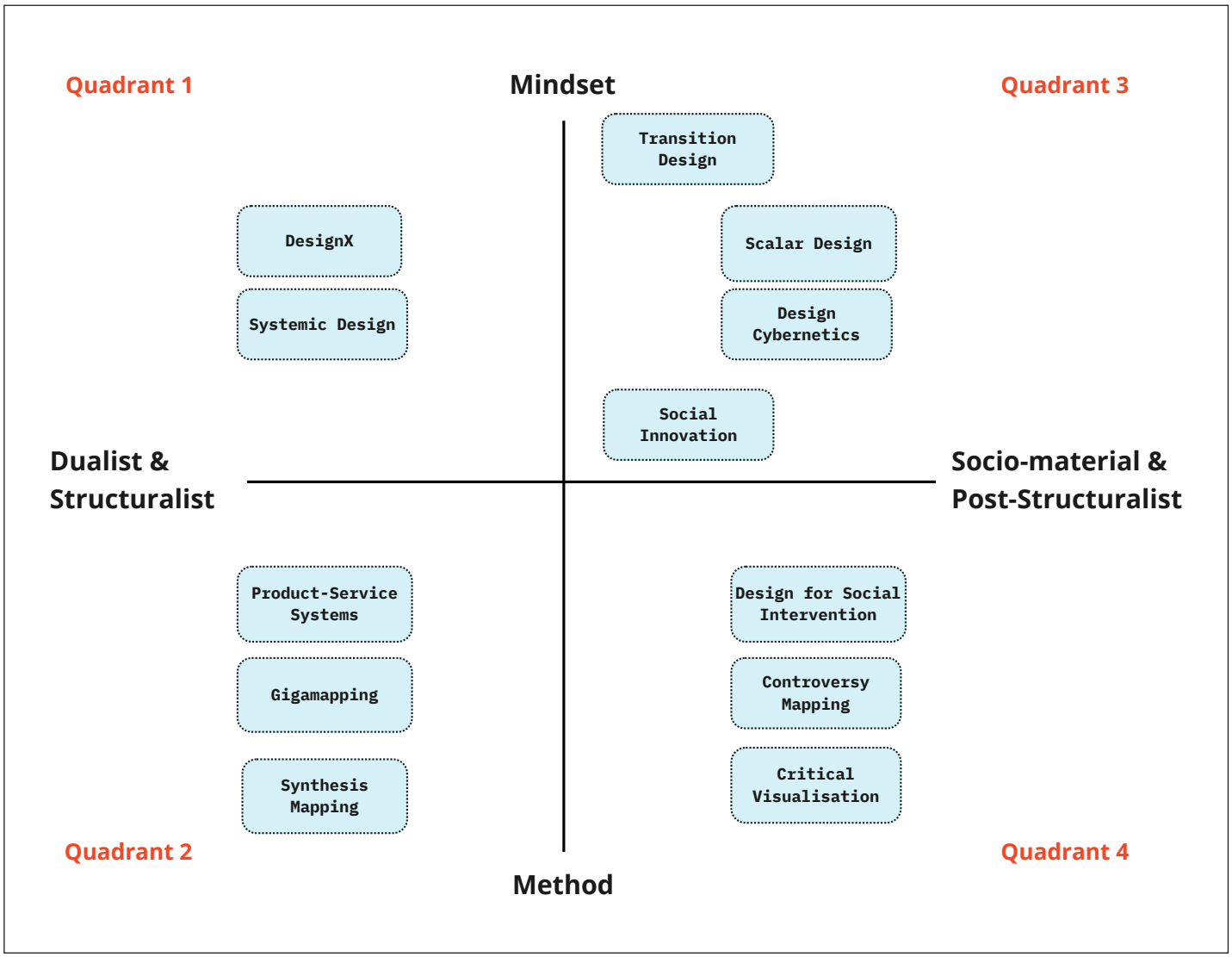
Systems thinking has supported designers conceptually to work on complex technical and organisational projects. Yet, this appears to have contributed to dematerialising and distancing design from being able to observe its own material impacts.

Towards a Socio-material Framework

This paper is a review of the academic literature around design and systems, as well as a step towards a socio-material framework for mapping 'articulations' of systems in design. By an "articulation", I mean a description of the way systems concepts are operationalised to offer a unique conceptual or methodological insight into design. This means that these articulations are not necessarily observable design practices but might be mere conceptual proposals. The reason for focusing on articulations is that 'systems' are largely a discursive concept with few acknowledged examples of systems design projects.

The framework proposed in this paper builds on a number of existing studies that have mapped systemic design around sustainability (Ceschin & Gaziulusoy, 2019; Pereno & Barbero, 2020). This study extends beyond a thematic focus on sustainability and is unique in trying to offer a socio-material analysis of systems in design. This socio-material focus is derived from Actor-Network Theory (ANT) (Latour, 2005; Law, 2004), which pays attention to the connections and disconnects made between nature and culture, machines and people. This theory enables a problematisation of the notion of the "socio-technical" as used by Ceschin & Gaziulusoy and Pereno & Barbero. By focusing on how the encounter between people and technology is framed, the study aims to highlight meaningful differences between systems articulations and remove the ambiguity around this topic. Its overall goal is to develop socio-material terms of reference for systems that will support more analytical discussions within design research and practice.

The framework (Fig. 1) proposes to classify design articulations of systems: its x-axis, "Dualist & Structuralist to Socio-material & Post-Structuralist", encompasses knowledge assumptions, such as "how to know systems", as well as assumptions about the nature of a system, such as "what systems are composed of". I use "structuralism" here as a wider epistemic tradition that started in linguistics and travelled into other social science disciplines. Its key point is that there is a central structure that defines the properties of its component parts instead of those qualities being possessed in isolation. Capra & Luisi have argued for the similarity between



↑ **Figure 1. The socio-material framework maps 12 design articulations along two axes: "Dualist & Structuralist to Socio-material & Post-Structuralist", and "Mindset to Method".**

sociological structuralism and the way early systems thinkers conceptualised 'whole' systemic structures. (Capra & Luisi, 2014, p. 299). In the framework, the x-axis represents an opposition between a knowable, centralised and structured system versus a post-structuralist notion of a messy system without an overarching purpose and only partially knowable. At the same time, the x-axis represents a distinction between a dualistic Cartesian approach that divides mind and matter, versus a socio-material approach that argues for hybrids of human/technology, hard/soft and partial/whole. My suggestion is not that, at a theoretical level, structuralism = dualism, or that post-structuralism = socio-materialism, but that in the literature around systems, there is a strong overlap between them, making it suitable to combine them on the same x-axis.

The y-axis, "Mindset to Method", indicates how a design articulation is applied methodologically. The notion of 'Mindset' is the "values and habits the systemic designer brings to the challenge, which guide judgement" (Ryan, 2014, p. 5), while 'Method' is used to indicate an applied "set of procedures for facilitating group process that specifies how group members should work together to generate and externalise ideas". (Ryan, 2014, p. 4). While some of the design articulations consist of both 'Mindset' and 'Method', many prioritise one over the other and are thus positioned accordingly on the y-axis.

Methodology

The review identified academic texts and grey literature about design and systems via searches for the terms "design + system" in Google and Google Scholar as well as searches using the term "system" in *She Ji*, *Design Issues*, *Design Studies*, *Design and Culture*, *Design Journal and International Journal of Design.* Recommendations were also sought from colleagues at the UAL Social Design Institute as well as identified via interviews with UAL colleagues about systems.[1] The 145 texts identified for analysis were summarised and clustered with others to form 12 distinct articulations of design and systems (see Fig. 1). Some of the articulations, such as "Systemic Design", have names designated by the authors, while others are a synthesis of multiple texts for which I have coined a name, such as "Critical Systems Visualisation". The criteria for the inclusion of articulations is the extent to which they propose a distinctive theorisation or methodological application of systems within design. The key metric is the specificity and uniqueness of the way in which an articulation configures the relationship between human/technology, hard/soft, inside/outside and partial/whole. In a hypothetical example of two papers — one of which treats systems as physical supply chains, while the other uses a metaphor of symbiotic mushroom colonies — they are distinct enough to feature as separate design articulations in the framework. Some design discourses such as "Circular Design" are not featured, because they encompass multiple different systems articulations (Earley, 2020) rather than representing a distinct articulation.

The resulting 12 design articulations are of unequal scale, scope and application. Some are textual manifestos such as "DesignX", while others such as "Social Innovation" are whole design networks, yet others are applied industrial practices such as "Product-Service Systems". The descriptions of the articulations in section four (from p. 11) of this paper use the same structure — context, problem space, case study example, system composition and methods.

Study Limitations

The study has four limitations. The first and main limitation is around the clarity of the socio-material framework and the suitability of the proposed XY axes. Input from other researchers could lead to more refinement of the framework. Secondly, the paper could benefit from a more detailed method for selecting and analysing the corpus. The third limitation is around the constrained historical perspective on systems ideas. Further analysis might identify the roots of the post-structuralist approach to systems. The fourth limitation is that the study only focuses on articulations rather than design practices. This means that it cannot identify what difference systems ideas make in practice. A follow-up study could use interviews and ethnographic observations to capture systems in practice.

Classic Systems Theories

The history of design and systems theories goes back to the early 20th century with cybernetics (Wiener, 1948) and complexity theory (Schrödinger, 2013), and reaches its heyday in the 1970s, which is the 'classic' systems period. The goal of early systems science was to find a universal set of laws (like thermodynamics) that govern all kinds of systems — everything from missile guidance to human societies. The search was for "principles applying to all systems in general, irrespective of

whether they are of physical, biological or sociological in nature." (Bertalanffy, 1968, p. 33). Many of these systems notions were derived from biological systems and analysed as mathematical models (Holling, 1973), and focused on cybernetic feedback loops (Wiener, 1948). A key transition of systems ideas into design was the 1968 Club of Rome conference (Jones & Kijima, 2018), which gathered economists and scientists to deal with global sustainability problems of resources and overpopulation. It spawned the book *The Limits to Growth* (Meadows et al., 1972), which popularised the idea of computer modelling systems behaviour as "systems dynamics" (Forrester, 2007) and led to the later idea of "leverage points" (Meadows, 1999) for intervening in systems. As a counterpoint, it also prompted *The Predicament of Mankind* (Ozbekhan, 1970), which focused on complementary modes of systems thinking and the necessity of stakeholder participation in designing systems. These two perspectives on systems represent 'hard' and 'soft' systems approaches (Cao, Clarke & Lehaney, 2003), where "'hard' systems thinking is appropriate in well-defined technical problems and that 'soft' systems thinking is more appropriate in fuzzy ill-defined situations involving human beings and cultural considerations" (Checkland, 2000, p. 17).[2] The 1970s saw the introduction of a number of different soft systems approaches in management and organisational studies. The most influential is Soft Systems Methodology (SSM) (Checkland, 1981), which is an action research management approach to analysing large companies and business sectors as systems. In contrast to the hard systems approach, where systems are assumed to exist physically in the world, SSM recognises knowledge uncertainty and multiple viewpoints and suggests that it is the researcher who is acting 'systemically'. Other 'soft' approaches such as Structured Dialogic Design (Laouris, 2012) focused on facilitating expert workshops, while Social Systems Design (Banathy, 1989) and Evolutionary Systems Design (Laszlo & Laszlo, 2002) imagined design as an evolutionary scale process that could shape societal values and connectedness. What is understood as design in these soft systems approaches varies tremendously from the designer as organisational consultant, workshop facilitator or a kind of design philosopher. The main relevance of soft systems today is the 'rich picture' method from SSM, which uses sketches to visualise systems dynamics. What is notable is its distinctive hand-drawn visual style of "fried-egg shapes and curved arrows" (Checkland, 2000, p. 19), which was intended "to undermine the apparent certainty conveyed by straight arrows and rectangular boxes" (ibid).

Across early theories of hard and soft systems, the shared idea is that systems are distinct entities, connected around a central purpose, which creates emergent complexity that their constituent parts do not themselves possess (Mele, Pels & Polese, 2010; Taysom & Crilly, 2017). The following quote offers a graphic illustration:

> Dividing the cow in half does not give you two smaller cows. You may end up with a lot of hamburger, but the essential nature of 'cow' — a living system capable, among other things, of turning grass into milk — then would be lost. This is what we mean when we say a system functions as a 'whole'. Its behavior depends on its entire structure and not just on adding up the behavior of its different pieces. (Kauffman, 1980, p. 2)

It is the coherence of systems that is said to create their emergent qualities:

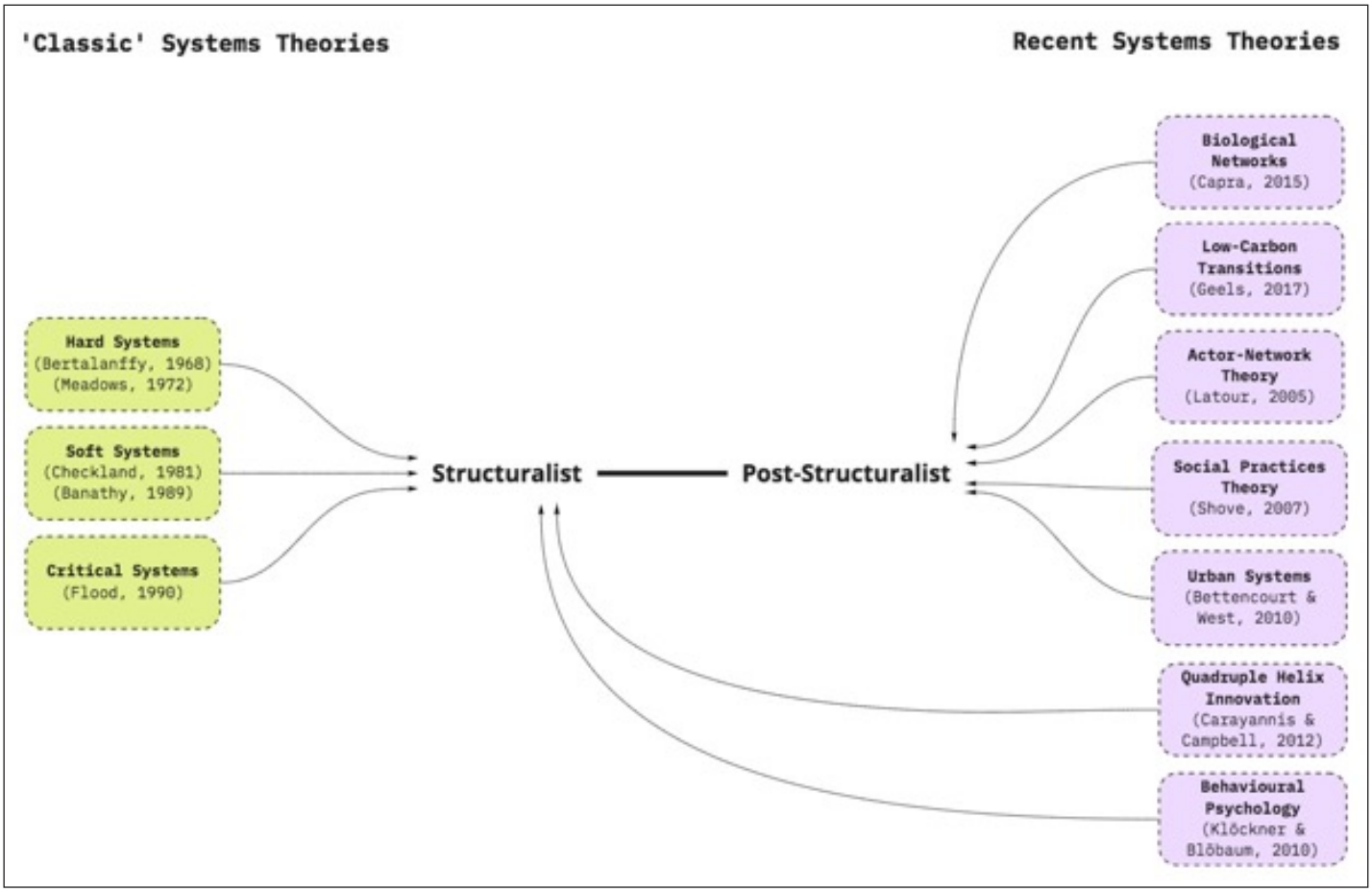
> Interdependencies between system components and their environment give rise to emergence, self-organisation, learning, adaptation, evolution, power law statistics, chaos, complexity, and other 'surprise-generating mechanisms'. (Ryan, 2014, p. 2)

In summary, the key concept from classic systems theories is that 'systems thinking' involves a 'holistic' overview of the 'whole system' (Ackoff, 1971) rather than its constituent parts in order to grasp the system's emergent qualities.

Contemporary Design and Systems

Today, design and systems is a vibrant area, with the most active discussions about systems design around sustainability. Design in relation to systems has become much more applied than earlier abstract notions of design, and extends across the spectrum of education and academia, as well as applied commercial and industrial design. The main hub for this discussion is the Systemic Design Association (SDA), which has its own conference and publications.[3] Individuals from this network have published *Systemic Design: Theory, Methods, and Practice* (Jones & Kijima, 2018), as well as a special issue of *She Ji* magazine (Sevaldson & Jones, 2019) and *Strategic Design Journal* (Barbero & Pereno, 2020). Yet, there are a number of significant systems design approaches that are not discussed within this hub and exist in their own networks.

↓ **Figure 2. The contemporary spectrum of systems theories in design extends across a Structuralist to Post-Structuralist divide from classic systems theories from the 1970s to more recent theories.**



Contemporary design makes use of a broad spectrum of systems concepts and theories that extend well beyond the classic systems theory canon (see Fig. 2). Designers are using ideas of Biological Networks (Capra, 2015), Low-Carbon Transition (Geels et al., 2017), Actor-Network Theory (2005), Social Practices Theory (Shove et al., 2007), Urban Systems (Bettencourt & West, 2010), Quadruple Helix Innovation (Carayannis & Campbell, 2012) and Behavioural Psychology (Klöckner & Blöbaum, 2010). Many recent systems theories are post-structuralist, where systems are distributed, unknowable and composed of socio-material hybrids of people and technologies. Capra and Luisi (2014), in particular, offer a history of systems theories that has been popular in design with its rejection of mechanistic systems and focus on nonlinear biological life networks driven by creativity and cognition.

This multiplicity of systems theories in design should be seen as a reaction against the restrictive classic systems ideas. Ethnographers of design such as Susan Star (1994) and Lucy Suchman (2002) argue that top-down approaches to systems ignored users and functioned poorly in practice to "produce technologies which embody a managerial perspective" (Berg, 1998, p. 462). Elizabeth Shove argues that tackling sustainability requires a focus on "social practices" (Shove et al., 2007) not just supply chains, while design theorist Peter Jones suggests that soft systems approaches were solipsistic, unrealistic and failed to tackle the wicked problems of climate change and global corporations (Jones, 2014). He argues that "social systems never evolved to become 'designerly'; with its roots in systems theory, its applications remained too abstract and removed from human behaviour. For too long we have included design thinking as a peripheral passenger in the systems journey" (Jones & Kijima, 2018, p. viii).

A common argument in the design literature is that, while systems thinking is valuable, it is actually opposed to design thinking. Jeffrey Tjendra, for example, argues that "design thinking is meant to innovate new solutions based on 'bottom-up' human-centered approach[es]. Systems thinking is meant to manage change and integration based on [a] 'top-down' big picture view" (Tjendra, 2018, para. 4). This dualistic characterisation of systems as mechanistic and top-down — while design is creative and human-centred — is found throughout the literature (Mononen, 2017; Pourdehnad, Wexler & Wilson, 2011; La, 2019; Ryan, 2014). It has meant that systems ideas have an unstable position within the design literature of being seen as important, but somehow alien to design practice. As a result, key systems phrases such as 'interconnectedness', 'synthesis', 'emergence', 'feedback loops', 'causality' and 'systems mapping' (Acaroglu, 2017), are often used by designers without a clear idea as to how to translate them into practice. The most succinct summary of this tension is by Buchanan who argues that "it is important that, once systems thinking and analysis has mapped the territory of a situation, systems thinking then quietly moves aside and systems thinkers turn to the practice of design to study human beings and create pathways of experience" (Buchanan, 2019, p. 100). The fact that this dualistic distinction appears in a significant proportion of the literature suggests that this separation is an important metric for classifying design articulations.

Mapping Articulations of Systems and Design

This section analyses the 12 articulations of systems and design identified via a review of the academic design literature and maps them in the socio-material framework (see Fig. 1). The paper follows the diagram from top to bottom in quadrant order starting from the top left quadrant.

Quadrant 1: Dualist & Structuralist Mindsets

DesignX

This design articulation was created by established design thinkers, Don Norman and Pieter Jan Stappers, as an approach for tackling "wicked problems" (Rittel & Webber, 1973). It frames systemic problems as issues of complexity that design is currently ill equipped to tackle since they involve millions of people and different kinds of technologies. Specifically, this articulation describes systemic problems as "socio-technical" involving a "mix of human and societal needs where solutions involve technology" (Norman, 2014, p. 4). The concept of systems being used is structuralist and based on a soft systems notion of a centralised and knowable system.

> Probably the most important characteristic of a DesignX problem is the existence of feedback loops. Feedback changes the behavior of the system, making it impossible to understand the whole through understanding each of its parts. Instead, the system must be analyzed for emergent behavior. (Norman & Stappers, 2015, p. 88)

Their insight is that human-centred design approaches can be added to systems thinking to deal with complexity. Yet their design approach is focused dualistically on the design of technology, while people's needs are understood through universalised, psychological patterns of human behaviour (Norman & Stappers, 2016). The goal of this articulation is to move the design discipline closer towards systems science by codifying its methods and combining human factors design with systems engineering. This design articulation is a manifesto without explicit methods being suggested.

Systemic Design

This articulation emerges from designers around the SDA and is associated with Politecnico di Torino, Ontario College of Art & Design University and Oslo School of Architecture and Design. Systemic design is an analytical approach for economic design modelling focused on environmental sustainability. It "aims to model production and energy systems after nature, since natural systems are efficient par excellence." (Battistoni & Barbero, 2017, p. S1339). Practically, systemic design involves analysing and mapping resource flows of geographic target areas with

the aim of achieving zero emissions. The outputs tend to be analytical Gigamaps (Sevaldson, 2018) that give a visual overview of a system. An example is a map of patisserie production (Battistoni & Barbero, 2017, p. S1343), which shows how ingredients are refrigerated, baked and decorated and how this produces grey water that ends up in sewers, and waste that ends up in landfill. The conceptual framing of a system in this articulation is as a physical supply chain where resources are entangled in networks of factories, markets and plantations (Battistoni & Barbero, 2017, p. S1344). Its stated concern is with the "whole system", meaning "the entire food's lifecycle and every stakeholder who takes part in it" (Barbero, Tamborrini & Dansero, 2015, p. 517), rather than any specific 'part'.

> A systemic project prevents focalisation only on one product and tends to privilege complexity, local dimension and flexibility. This enables to revitalize and resume the normal links between each firm and its own context, based on the outputs it has produced, and to prioritise the decrease in the number of items that have not been adequately enhanced (waste). (Barbero, Tamborrini & Dansero, 2015, p. 520)

Theoretically, this approach references classic systems theories from (Schrödinger, 2013) and General Systems Theory (Bertalanffy, 1968). Human behaviour and actions appear in this design articulation as company decisions about flows of resources on a zoomed-out view of resource management. This design approach is conceptual but also offers case studies that show how it can be applied as a method for visualising systems for intervention via circular systems.

Quadrant 2: Dualist & Structuralist Methods

Product Service Systems

This concept was initiated in academia and became successful as a practice within industry (Cook, Bhamra & Lemon, 2006; Sakao, 2011), circular design (Moreno et al., 2016; Fernandes et al., 2020), as well as in community-focused design in the DESIS network.[4] The concept is premised on turning design products into services. Peruzzi and Germani (2014) offer the example of moving from selling heaters to selling hot water as a service. The client no longer buys a product, but its utility. The claimed benefit of this approach is sustainability, since the overall system uses fewer raw materials and creates less waste (Manzini & Vezzoli, 2003). The logic is that "sustainability is a system property and not a property of individual elements of systems" (Ceschin & Gaziulusoy, 2016, p. 119). The role of design is that of "aiming at an integrated system of products, services and communication", (Manzini & Vezzoli, 2003, p. 856) with method toolkits (Verkuijl, Tischner & Tukker, 2006) offering guidance. The notion of the system is as a static knowable entity that combines energy networks and supply chains, as well as networks of stakeholders. Yet, the technological and human parts of the system are treated differently, making this approach dualist and structuralist.

Gigamapping

Visualisation is a common element of design, yet there are specialised visualisation methods for systems such as Gigamaps (Sevaldson, 2018). This approach has become the mainstay of the Relating Systems Thinking and Design network.[5] Gigamapping is "a technique for collaborating groups to map, contextualize, and relate complex systems, revealing their environment and landscapes (of interaction), their current states, as well as preferred future states" (Sevaldson, 2018, p. 243). The maps are commissioned by organisations looking for insights into their specific domain. The design process is premised on bringing together different actors to create a collaborative Gigamap to act as a bridging tool between different stakeholder expertise, knowledges, models and fields (Sevaldson, 2018, p. 249). The design approach is codified and includes a Library of Systemic Relations, as well as a formal means for dealing with 'ruptures' of disagreement amongst the stakeholders. Sevaldson argues that Gigamapping is an extension of the Soft Systems Methodology in terms of facilitator-led events and a 'rich picture' approach (Sevaldson, 2011). Yet, it goes further in terms of trying to reproduce the complexity of a system at a representational level:

> [Giga]maps try to grasp, embrace and mirror the complexity and wickedness of real life problems. Hence they are not resolved logically nor is the designerly urge for order and resolved logic allowed to take over too much and hence bias the interpretation of reality. (Sevaldson, 2011, p. 138)

The Gigamapping approach suggests that systems can be rationally analysed and explicitly mapped, which makes this method a structuralist articulation. While Gigamapping is largely confined to visualisation, there are experiments that iterate visualisation with practical prototyping (Davidova, 2020).

Synthesis Mapping

This design articulation is closely related to Gigamapping. Where this method differs is that design takes place within educational settings rather than sponsored client stakeholder contexts, and works with studio design pedagogies to construct the maps (Jones & Bowes, 2017). In addition, synthesis maps have more reflexivity regarding the role of the designer in the way that they use graphic metaphors to communicate the overall message of the maps. For example, a map about digital media culture, titled "Is it time to pull the plug?", is arranged into the shape of a lightbulb with a graphic of a cable trailing to an electrical socket. Such illustrative elements are absent from Gigamaps, which make synthesis maps look more like the information visualisations one might see in newspapers. Yet Jones and Bowes suggest that "synthesis maps are more than system models or infographic simplifications of complex scenarios. They follow systemic principles to disclose and critique the entanglements of the complex problem that they reveal" (Jones & Bowes, 2017, p. 239). Nevertheless, it is this interpretive communication layer that positions this method partway towards a post-structuralist approach to systems.

Quadrant 3: Socio-material & Post-Structuralist Mindsets

Transition Design

This articulation is associated with Carnegie Mellon University and the Transition Town movement in the UK.[6] Its focus is on the "longer-term visioning and recognition of the need for solutions rooted in new, more sustainable socioeconomic and political paradigms" (Irwin, 2015, p. 230). While related to 'service design' and 'design for social innovation', it operates at a more abstract level and longer timeframe.

> Transition Design proposes that, in order for designers to act as agents for change, new approaches to design and problem-solving must be based upon a deep understanding of the dynamics of change within complex social and natural systems. (Irwin, 2015, p. 234)

The concept is a notion of a 'societal mindset transition' where "living in and through transitional times calls for self-reflection and a new way of 'being' in the world. This change must be based upon a new mindset or worldview and posture (internal) that lead to different ways of interacting with others (external) that informs problem-solving and design" (Irwin, 2015, p. 235). Irwin and colleagues illustrate this approach via an example of tackling childhood obesity at three design levels: the design of a physical food tray, a systems level, and a transition design approach that operates at the level of culture (2015). Transition design proposes 'culture' as its object of design, which is conceived as a level above systemic resource flows. Designing at a cultural level involves the "the redesign of regional or even national policies and infrastructure" (Irwin, Tonkinwise & Kossoff, 2015, p. 9). The theoretical basis for this articulation is derived from "low-carbon transition" (Geels et al., 2017) and "social practices" (Shove et al., 2007), as well as biological notions of evolution as cognitive self-organisational processes (Capra, 2015). When Irwin talks about "holistic", she does not mean a top-down view of the system, as in classic systems theory but, rather, a non-Cartesian mind/body connection with the "interior, invisible dimension of human experience" (Irwin, 2015, p. 235). In this approach, the role of the designer is as a facilitator of expert stakeholders "envisioning future scenarios for sustainable everyday life" (Richardson, Irwin & Sherwin, 2005, p. 17). While transition design is non-Cartesian, its approach to knowledge about systems is expert-led and might be best characterised as institutional.

Scalar Design

This articulation is associated with Jamer Hunt and the Transdisciplinary Design course at the Parsons School for Design in New York. The central idea is that 'scale' is complex and can surprise and disrupt wicked problems. Thus, tackling public education looks radically different "starting at the scale of the students, or the class-room, or the school, or the school system, or the local, state, or national government" (Hunt, 2020, pp. 10–11). Hunt uses a notion of scale from ANT where there are no distinctions between micro and macro and each is recursively contained within the other (Callon & Latour, 1981). Hunt provides a conceptual example of the design of a bag, which, he argues, is simultaneously a physical

artefact as well as an economic system. He suggests design involves maintaining a balance between part and whole, where "only by juxtaposing these two scales of action and holding them in a productive tension can one begin to address the vicissitudes of the challenge" (Hunt, 2014, p. 9). What is novel about this articulation is that design practice itself is framed as creating systemic changes at multiple levels without any need for 'scaling up'. This means, "designing for systems is not the same thing as designing artifacts. It is not simply a matter of a linear increase in scope and scale. It is a qualitatively different act" (Hunt, 2014, p. 2). Hunt's notion of systems is as "an inchoate assemblage of mutually influencing actors and actants, moving in unanticipated directions and affected by the social equivalent of fluttering butterfly wings" (Hunt, 2014, p. 6). Scalar design offers a post-structuralist mindset that frames systems as "a gooey mass of radical uncertainty" (Hunt, 2020, p. 214) that cannot be tackled through top-down systems planning. What is needed is an 'attunement' to systems as a "reassertion of the primacy of the body in coordination with mind as a means to embrace complexity more humbly and more fully" (Hunt, 2020, p. 214). Scalar design is thus a conceptual translation of ANT ideas into a design language, yet without offering practical methods for doing so.

Design Cybernetics

This contemporary form of cybernetics-inspired design is part of a broader re-assessment of early 20th-century cybernetics as offering countercultural experimentation rather than mechanistic top-down control (Pickering, 2010). In particular, the idea of conversation theory developed by British cybernetician Gordon Pask, and his students Ranulph Glanville and Paul Pangaro, has been influential for design (Werner, 2019). Glanville describes "design as a practical expression of cybernetics, cybernetics as a theoretical study sustaining design" (2009, p. 175). Dubberly and Pangaro (2015) argue that all design involves making systems and can take place at all scales. Even apparently simple activities such as sketching involves a cybernetic system feedback between the pencil, oneself and paper (Glanville, 2009). Using the notion of second-order cybernetics, which includes the observer as an active participant, they describe systems not as mechanistic but a "messy chaos of natural and social systems" (Dubberly & Pangaro, 2015, p. 74). They suggest that second-order cybernetics makes explicit the subjective position of design and reframes the process as a conversation to converge on shared goals. This approach takes concepts from historical systems theory such as cybernetic feedback loops but frames them as a reflexive process that highlights designer subjectivity and responsibility. This is a post-structuralist formulation of a system where knowledge is situated and partial as in "standpoint epistemology" (Harrison, Sengers & Tatar, 2011). Instead of offering explicit methods, this approach suggests the need for a new design skill of 'systems literacy', which "must go beyond SD [systems dynamics] and incorporate goals and agency. Designers must therefore understand the workings of systems with agency" (Dubberly & Pangaro, 2015, p. 75). This literacy is designed to offer agency in response to systems. Krippendorff (2007) offers some practical methodological insights into how to design using a second-order cybernetics approach, but this is largely a conceptual articulation of design and systems.

Social Innovation

This articulation comes from Scandinavian design and the DESIS Network founded by Ezio Manzini (2015). It focuses on innovation that involves designers as well as community groups and local businesses in the creation of new community services such as car-pooling, community gardens and local currency systems (Telalbasic, 2017). Its notion of innovation is focused not on commercial profit but aims to "meet social needs and create new social relationships or collaborations. In other words, they are innovations that are both good for society and enhance society's capacity to act" (Murray, Caulier-Grice & Mulgan, 2010, p. 3). The design process is framed as participatory design or co-design that includes communities as well as material entities and involves "facilitating the careful building of arenas consisting of heterogeneous participants, legitimising those marginalised, maintaining network constellations, and leaving behind repertoires of how to organise socio-materially" (Björgvinsson, Ehn & Hillgren, 2012, p. 143). The notion of a system is as a socio-material network drawing on ANT literature, where design creates a "collective interweaving of people, objects and processes" (Björgvinsson, Ehn & Hillgren, 2012, p. 130). In Manzini's formulation (2015), social innovation creates a "project-centred democracy" focused on civic material participation (Tonkinwise, 2019). This articulation uses the notion of infrastructure from design ethnographer Susan Star (1994) as a verb — "infrastructuring" — where the designer is actively creating infrastructural systems. An example from the literature is a catering service for Afghan refugees in Sweden, which highlights systemic relationships (Hillgren, Seravalli & Emilson, 2011). This articulation also incorporates political theory of "agnostic pluralism" (Mouffe, 2000) to frame systems as spaces where democratic conflicts can be facilitated and do not need to be resolved. This articulation is post-structuralist in the way in which it frames systems knowledge as partial and contested. While theoretically focused, the articulation also includes a social innovation toolkit (Murray, Caulier-Grice & Mulgan, 2010), as well as suggesting ways to use existing design methods such as cultural probes (Gaver et al., 2004) as part of social innovation processes (Manzini & Cipolla, 2019).

Quadrant 4: Socio-material & Post-Structuralist Methods

Design for Social Intervention

This articulation was created by US designers and community activists and is distinctive for the way that systems are used as a practical tool for an interventionist political and decolonising agenda.[7] In the book *Ideas Arrangements Effects: Systems Thinking and Social Justice* (Design Studio for Social Intervention, 2020), the authors align themselves directly with systems thinking and a socio-material approach to systems. Specifically, they use the ANT notion of 'arrangements' to suggest that these are systemic structures that shape social action and can also be redesigned at a material level to create social justice. The group's praxis combines writing and public action labs events with marginalised communities such as the *Social Emergency Response Center Manual* (Design Studio for Social Intervention, 2017). This approach uses the notion of socio-material 'arrangements' to provide guidance for organising the infrastructure of creating a community space to include "radical welcoming" and "plotting and cooking teams" (Design Studio for Social Intervention, 2017, p. 14), and how to arrange seating and information signs. In an earlier booklet, they offer procedures to follow in case of a social emergency: "Just

as fire drills train us for how to act and what to do in case of a physical emergency, we need drills and steps for how to act when there's a social emergency. (And in case you were wondering, this IS a social emergency" (Bailey & Lobenstine, 2015, p. 279). In this articulation, the notion of the system functions as a materialised arrangement of democracy as a design problem that can be tackled at an infrastructural level. This articulation is explicitly post-structuralist in its participatory, open-ended notion of systems and highly practically orientated in providing methodological guidance.

Controversy Mapping

This method originated from the Sciences Po in Paris and University of Amsterdam (Marres & Moats, 2015; Venturini et al., 2015; Venturini, 2012). It is the most explicit application of ANT to design, where it is used as a hybrid design and social science method for interrogating public controversies such as climate change. What is significant is how the socio-material ANT notion of agency as something that both human and non-human actors possess is used to support the visualisation of systems. A conceptual example from the literature is the way that the design of a hotel key fob turns it into an 'actor' that governs the behaviour of hotel guests by preventing them from taking the key away from the hotel (Latour, 1991, p. 105). Applied to the visualisation of systems, this means that there are no obvious starting points for what is an actor or the scale at which to map a system. Should the designer map the daily work of employees, its managing directors, shareholders, the internal email traffic or, perhaps, the ecological footprint of a company? The scope, scale and boundaries of a system are based on the interactions that the mapmaker can themselves observe about the system. This theoretical approach also places disagreement at the centre of systems visualisation to highlight that "not all positions are equal and actors fight to build and occupy influential positions: positions that give them the power to affect the actions of other actors" (Venturini, 2012, p. 798), and offers concepts such as a "tree of disagreement" for visualising an "archaeology of disagreement" (Venturini, 2012, p. 805). In summary, controversy mapping should be seen as a theory-driven post-structuralist and socio-material method that adds nuance to the visualisation of systems.

Critical Systems Visualisation

This articulation is a synthesis of a number of approaches that problematise the visualisation of systems. It builds on a long history of critical systems maps created by designers (D'Ignazio & Klein, 2016), artists (Nold, 2009), and critical (Crampton & Krygier, 2006) and feminist geographers (Kwan, 2007). Jun, Kim and Lee (2011) offer a taxonomy of systems visualisations: using hierarchy as an organising principle, guiding decision-making, providing affordances and enabling transcendent ideas. In contrast, critical systems visualisation offers another approach, using visualisation to challenge the representation of systems and presenting alternative notions of systems. Lockton and colleagues (2019) focus on "materialising systems" to create physical models to allow systems to be experienced, something that they see as missing from other systems visualisations. This involves constructing three-dimensional models from basic improvised materials to act as '"visual prostheses" (Jonassen & Cho, 2008) for sharing mental imagery with others. These visualisations use the expressive and metaphorical qualities of the material to articulate aspects of a system:

> The differing qualities of varied materials became prompts and props for storytelling, and participants acted with materials in a way provoked both by their physical properties and by their dynamic connection. (Lockton et al., 2019, p. 17)

This approach does not aim to be informationally all-encompassing, but to have an experiential impact on the viewer, which shifts systems representations into a performative realm. The authors describe this approach as a critique of the Gigamapping approach, which claims representational neutrality. In contrast, materialising systems allows expression and positionality on the systems being presented:

> Climate change as an 'inevitable storm front' is experientially different [to] climate change as an arrow on a diagram. This suggests the value of tangible thinking tools for exploring the experiential side of systems — what do they 'feel' like from the inside? (Lockton et al., 2019, p. 10)

What is notable about this approach is that it does not just represent systems, but suggests that systems are composed of different elements such as the perceptions and articulations of participants. This articulation offers methodological specificity since it aims to use systems visualisations as a performative means of remaking systems. It is post-structuralist because it works against claims of objectivity, neutrality and the universalism of representation, suggesting that systems are contested, and that knowledge is partial and distributed.

Discussion

This working paper contributes to the discussion about design and systems by developing a set of socio-material terms of reference in the form of a framework that helps to differentiate and map systems articulations found in the design literature. The study offers the following three tentative insights around the intersection of design and systems.

The multiple notions of systems are incommensurable

As discussed in the introduction, there is a high level of ambiguity about systems in design. When contemporary designers and design researchers talk about systems, they use a variety of ideas from commonsense notions to specific academic discourse that varies between mathematical models of industrial supply chains, public service organisations and messy metaphors of non-human organisms. Much of this diversity can be attributed to the complex history of systems theories from the early 20th century and the distinct epistemological split between structuralist and post-structuralist approaches around "how to know systems". This tension can be seen as running across the history of the last 50 years of design and systems.

The structuralist approach claims that systems are easy to identify due to their 'naturalistic' complexity, since they involve large organisations full of people and technologies. Systems are imagined as large structures constituted around a

central purpose, which creates emergent complexity that constituent parts do not themselves possess. It is thus the whole 'structure', boundary and scale of a system that is important. The designer's role is to help make systems knowable and to improve them — as described in "DesignX" and "Systemic Design".

In contrast, in the post-structuralist approach, systems are not obvious because they do not look like technical or organisational mega structures. Instead, systems can exist in vastly different forms, domains and scales — even at the level of hand, eye and brain coordination as seen in "Design Cybernetics". The system does not have a rigid centralised structure, boundary or scale but is imagined as operating as an assemblage, network or rhizome of entities in coordination. What matters from this perspective is that how one interacts with a system changes one's perspective on it. Yet, ultimately, the system as a whole is messy and only partially knowable from a situated perspective. The designer's role in this approach is as a performative actor who needs to learn to 'feel' systems in order to be able to transform them from within — as described in "Scalar Design" and "Design Cybernetics".

This distinction can be illustrated in the way that Silvia Barbero and colleagues (2015) and Terry Irwin (2015) both use the word "holistic" to describe systems but actually mean radically different things. The former uses "holistic" to describe a "whole systems" view of a rationally knowable system in line with general systems theory (Bertalanffy, 1968), while the latter uses "holistic" to describe an integration between human interiority and an external environment, derived from non-linear biology and oriental philosophy (Capra & Luisi, 2014). This represents both an epistemological difference around "how to know systems" and an ontological difference in "what systems are composed of". Barbero adopts a dualist perspective where systems are made of inert raw materials that can be optimised by human ingenuity to make a system run better, while Irwin envisages a socio-material assemblage of human and nonhuman actors that are dynamically co-constructing the world together.

The importance of this dualist versus socio-material distinction becomes clear when one examines large and complex projects such as public services, healthcare and transportation. While all design articulations agree that these kinds of projects involve technical and social aspects, there is disagreement as to how to deal with this combination. In dualist design articulations, the hyphen in the word "socio-technical" is used to indicate an encounter between the 'social' AND 'technical', yet each remains stable and separate. This means that they are tackled using different methods; the social is handled by discussion, while the technical involves problem-solving, while, in contrast, socio-material design works with the notion that "technology is society made durable" (Latour, 1991), where the social and the technical form an indivisible hybrid, where the social IS technical and the technical IS social. This fundamental question about the nature of technology and mind/body dualism has practical everyday implications.

> Our engineering designer sees systems as tangible parts of the world that can be re-engineered, while our experience designer sees systems as a way of organising their thinking about a situation that is messy and problematic, but not composed of any physical systems. (Ryan, 2014, p. 2)

This quote illustrates how socio-material orientation repositions where systems and complexity are located. If a problem is a 'hard systems issue', then its complexity is in its hardware, while a 'soft systems issue' can be unlocked through discussion. In contrast, a socio-material analysis would suggest that problems stretch across these sites. Such practical examples of the effects of dualism in design raise doubts about Ceschin and Gaziulusoy's classification of system design approaches as a gradient between technology and people (Ceschin & Gaziulusoy, 2016, p. 144). They argue that, as design becomes more systemic, it becomes less technological and more people focused. Interestingly this actually inverts the popular characterisation of systems as mechanical. This raises doubts about the explanatory power of the popular claim that design is 'human-centred' and suggests that socio-material approaches to systems may enable more nuanced discussions of systems that can allow designers to see that all design is potentially systemic — whether working on social services or artefacts.

Unlike the scientific approaches of the 1970s systems era, contemporary design uses systems ideas as a pragmatic means to an end (Jones & Kijima, 2018), rather than aiming at theoretical purity or depth of engagement. In fact, many design papers cite systems theories that have contradictory epistemic framings within a single paper. What seems to be missing or underutilised is a coherent translation layer between primary systems theory and design practice. Key to that would be establishing more examples that demonstrate different notions of systems in practice. What is needed is more clarity and specificity as to the nature of the system assumed or intended by the designer.

Visualisation is the dominant method for engaging with systems

It is notable that, from the origins of the 'rich picture' in soft systems, visualisation has become the main design method for engaging with systems. The dominant approach across the literature is an attempt to capture systems naturalistically as a bird's eye view of the 'whole' system, as seen in Gigamapping. Fundamentally then, visualisation functions as a structuralist method for knowing a centralised system or at least suggesting its knowability. Yet, there are design articulations that offer post-structuralist visualisations that enable reflexivity and a situated positioning towards systems such as "Critical Systems Visualisation" and "Controversy Mapping". Nevertheless, design methods for engaging with systems via 'immediate' means (Keinonen, 2009) are less visible in the literature. However, as we have seen, socio-material concepts such as 'infrastructuring' from "Social Innovation" and 'arrangements' from "Design for Social Intervention" can enable design to reclaim its expertise with material practices and allow it to enact systems directly.

Systems thinking is changing the nature of design

Many of the design articulations suggest that design's engagement with systems is a result of a shift towards working in large multidisciplinary teams on complicated technical and organisational infrastructure projects. Many designers acknowledge that their "role is very different from producing the traditional craftwork that originally characterized the design profession" (Norman & Stappers, 2015, p. 84). Systems thinking can be seen as a way to deal with the complexity of actors and relationships

in these contexts. Yet, there is a sense that its introduction has caused a shift in the nature of design, becoming a knowledge practice or knowledge broker rather than material practice. Increasingly, designers are placed in the role of facilitating expert stakeholders, a role previously occupied by management consultants (Burns et al., 2006). Systems thinking has played a part in creating what Keinonen calls "remote design" (2009), where:

> Remote designers work for general solutions, principles, or understanding over individual contexts or implementations. They create conceptual, infrastructure, methodological, regulatory, competence, or resource-related foundations for others to develop products or local practices. (Keinonen, 2009, p. 71)

Thus, systems thinking has contributed a conceptual basis for design to operate at a discursive and strategic level long removed from its craftwork roots. In this shift, design is adopting a structuralist role of facilitating and visualising knowledge rather than directly creating material transformations. More specifically, the structuralist and dualist versions of systems thinking have generated a distancing, where designers can no longer directly observe their impacts on the world.

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Endnotes

[1] https://www.arts.ac.uk/ual-social-design-institute.

[2] There is also a less discussed third category of ‘critical systems’, which is Marxist-inspired (Flood, 1990).

[3] https://systemic-design.net.

[4] https://www.desisnetwork.org.

[5] https://rsd9.org/gigamap-exhibition.

[6] https://www.transitionculture.org.

[7] https://www.ds4si.org.

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