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Can design management for sustainability be the outcome of an innovative mix of design thinging and systems design?

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Based on the international consensus that mankind is facing an existential crisis of its own making, at the meta level of the United Nations seventeen sustainable development goals (SDGs) have been issued. At the meso and micro levels of organisations and people there is a similar agreement on design for sustainability (DfS) to care for people and the planet. The tools and methodologies which have been proposed in the design thinking (DT) and design management (DM) field have neither satisfactorily addressed the challenges of DfS in academia nor in business. For instance DT has been increasingly criticised since the 2010s and its death has been pronounced many times. This zombie concept from a design perspective has nonetheless remained indispensable for business leaders and entrepreneurs trained in non-design disciplines such as management or engineering. They have clung to DT for an easy-to-understand framework, practical tools and methodologies in order to climb the DM staircase towards innovative products, services and organisations.

DM and DT approaches of DfS have strived to, but by and large have failed to, address the current ecological and social challenges. It has been increasingly documented since the beginning of the 21st century. Two emerging approaches of DfS are discussed. First we present the emerging framework of systems design as an application of systems thinking to DfS. Second we introduce three instances of the reappropriation of the Heideggerian concept of "thinging" as contributions to infrastructuring DfS. They have not yet coalesced and are represented by a limited but expanding set of recently published material.

Based on weak signals and emerging trends, systems design and design thinging are more transformative, radical and speculative than mainstream DM and DT articles have been so far. The two authors acknowledge that the systemic and cultural scope of design management for sustainability (DMfS) goes beyond mere improvements of DM and DT and could cause paradigmatic shifts and turmoil. The authors have applied problematization to critically look at existing theories and literature streams and to formulate insights. This paper aims to be a milestone on the way towards DMfS and revolves around two main principles. First it considers two levels and their circular interconnection. It starts at the micro level of the embodied ways of thinking and doing of people. Then it proceeds to the meso level of organisations as strategic and dynamic infrastructuring of participatory design. It eventually closes the loop across the two levels with an interpretation of design as an intelligent orchestration at each level and between them. The goal of the complex DMfS process is thus set to generate resilient translational systems. Second it recognizes the in-discipline of design. Thus it calls for DMfS to open up beyond its two sub-component disciplines and to let interdisciplinary paradigms emerge from cross-pollination with human and non-human sciences..

***Keywords**: design management, design thinking, design for sustainability, systems design, design thinging*

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Introduction

Society 5.0 (2021, Unesco) faces substantial challenges to transform our relationship with the natural environment. To support this transformation, the United Nation's (UN) Sustainable Development Goals (SDGs) provide a common direction (Griggs, Stafford-Smith, Gaffney, Rockström, Öhman, Shyamsundar, Steffen, Glaser, Kanie, & Noble, 2013). They are a requisite in order to balance economic development and the resolution of social issues through a human-centred approach (Deguchi et al., 2020). Design Management (DM) can, and should, contribute to fostering new skills that need to be appropriated by professionals in order to address the challenges of deploying Environmental Social Responsibility (ESR) requisites in their organisations. "Society 5.0 [...] calls for possible learning competencies within all four domains [simple, complicated, complex and chaotic]" (2021, Unesco). The Cynefin framework (Snowden & Boone, 2007) gives cues for the decision makers to handle problems in these four domains. The integration of design methodologies is particularly appropriate to deal with the category of complex problems arising from the implementation of ESR rules and principles. Design Thinking (DT) can be thought of as a heuristic and critical human-centred process for decision-makers and as an asset for the development and in the implementation of DM.

Our research shows that there is a consensus in the design, management and DM academic communities that DM *for* Sustainability (DMfS) is still too marginal a concern versus DM as a value generator for profit. But there is a growing awareness and an increasing social pressure to implement ESR. Therefore the demand for more research in the field of DMfS is pressing, and so is the development of methods and tools for professionals and decision makers.

In the emerging field of DMfS, we have focused on two trends. The first trend of systems design has gained traction in the past twenty years. Design thinging is the second emerging trend that has yet to overcome its status of weak signal. Systems design draws on the natural sciences and proceeds by framing a particular system and drawing practical boundaries around it in order to build adapted and adapting self-organisations. In turn, these socio-material-assemblies are capable of generating boundary objects and eventually designing things. Design thingers need to be acquainted and to be able to interact with specialists in the two disciplinary fields of the humanities and social sciences (HSS) and of the natural sciences.We propose an integrative approach to Design Management for Sustainability (DMfS) to operationalize the adequate cultural framework to design processes and tools to contribute to the achievement of SGDs.

An historical perspective

From design and management towards design management in the 20th century

Since its inception at the Bauhaus in 1919 modern design has been concerned with its social responsibility. It has also had a tradition of dealing with "ill-structured" (Simon, 1969) or "wicked" (Rittel & Webber, 1973) problems. In 1969, Herbert Simon viewed the world as "much more a man-made, or artificial, world than it is a natural world" and design science as an essentially *systemic* "science of the artificial" (italics added, Simon described the world as "a particular system [that] will achieve a particular goal"). The history of management has been rooted in the Taylorian concept of "scientific management" (1914) and has continued to embrace mechanistic worldviews after World War 2. This attitude has gradually evolved in the second half of the 20th century from the firm as an "automatic factory" through a "cybernetic factory" to the more organic metaphors of "brain" and "heart". For instance, Vahidi, Aliahmadi and Teimoury (2018) reported on the field of cybernetic management (Beer, 1959) as an instance of a development of scientific management. Its initial purpose, which was to design "automatic factories" based on mechanistic principles, had evolved into a digitally inspired concept of "cybernetic factory" (Beer, 1962) based on mathematics, psychology, biology, neurophysiology, communication theory, anthropology and philosophy. It was then influenced by the natural sciences and developed a "viable system model" (Beer, 1972) and a neurocybernetic theory of the "brain of the firm" (Beer, 1972, 1981). It was eventually transformed in a metaphoric organic instance from a brain to the "heart of enterprise" (Jackson, 2007) to take into account "states of reasonability" integrating bounded rationality and emotions. The three authors concluded that the viable system model is "a beneficial methodology for designing and analyzing a vast diversity of complex socio-technical systems" in the fields of information technology, policy making, production, social issues, etc. In other words, it has led to recognise the class of problems addressed by management to be of a similar nature as design issues, i.e. "complex socio-technical systems". Hatchuel acknowledged in 2002 that Simon's research based on "operations research, micro-economics and statistical theory" has contributed to design theory. But he argued that his program was "unfinished"

because of “Simon’s limited interest in the construction of social interaction”. Therefore, and even though he was interested in, and competent in, design and management, his “unfinished program” could not provide satisficing answers to two of the main questions addressed by DM: “What makes that a company has a better design process than another?” and “What are the consequences of design theory on organization theory?”.

Design as a science of the artificial is also, and in itself, cultural as “symbol systems are almost the quintessential artifacts”. Simon was also concerned with the impact of human activities on “the world-wide society that our species has created” and with the corresponding and “growing need to understand and cope with some of the world's large-scale systems”. This “growing need” of the late 1960s has grown to an existential extent since the beginning of the 21st century. It came with the realisation that was imposed on us all by the planet that the post-industrial artificial world is indeed cultural but also part of the natural world. The artificial world is both impacted by it and impacting it. Hence sustainability has become a major goal for humanity, as proclaimed in the SDGs. The main concern of design in the 20th century was to conceive better products and the main concern of management was to produce better. Mass production allowed developed countries to become consumer societies or post-industrial societies. It was an answer to the two main challenges around production. But an undesirable rebound effect of that unlimited production and consumption is the depletion of natural resources and life-threatening pollution. Hence the new challenge is no longer the growth of human activities but their sustainability.

Towards design management for sustainability in the 21st century?

Real-world problems are more often than not messy and have resisted linear logical approaches. As Simon demonstrated, human rationality is bounded. Hence human understanding of real-world problems is limited. These boundaries should be recognised in order not to succumb to rationalisation “the building of a coherent totalising vision from partial data and a partial vision”; i.e. the “irrationality of rationalisation” (Morin, 1982). The Frankfurt School has shown that critical rationality should tame the instrumental reason. The two main limits of “engineering design” (Coateana, Forest & Choulier, 2010 call the C-K Theory developed by Hatchuel, Le Masson and Weil since the 2000 “engineering design” that “offers an interesting distinction between concepts and knowledge”) are that it is ignoring the historical and collective dimensions of the design activity as well as the cultural linkage of “the external representations and their reinterpretations” with reasoning. In a nutshell, it lacks cultural and social grounding.

Thus other less structured approaches could be more fitting with the fuzzy logic of designers and their simultaneous “thinking and doing” (Buchanan, 1992, “the theoretical opposition between design thinking and design doing shall be overcome by a reflexive approach of what design does, and not of what design is”). In fact, Rolf A. Faste (1994) proposed that, “when problem solving becomes blocked at the symbolic level, humans must revert to the right brained abilities associated with these previous stages” of the Piagetian theory. In this perspective, DT involves not only thinking with the brain but also thinking with the body; i.e. “ambidextrous thinking” by “reflexive practitioners” (Schön, 1983). DT’s objective is “to create a new ‘something’ [i.e.] a ‘thing’” by “‘open’ form of reasoning […] in the [‘field’ of the] organisation” (Dorst, 2011). This definition of DT embedded in the organisation is similar to a vision of DM where designers play a more important role than managers who, even though they are “surrounded by artifact”, fail to “accept the fact that objects dominate their world” and are “often incapable of appreciating the importance of ‘things’” (Borja de Mozota & Wolff, 2019).

Organisations are called to perform transition management in order to meet their ESR objectives (Loorbach, 2010). It requires analytical, evaluative and experimental approaches (Loorbach et al., 2017), but the related practices are often focused on linear problem solving and ignore the management of conflicting relations (Voß & Bornemann, 2011). Decision makers in organisations can no longer ignore the complexity of the world and of the situations at hand. Businesspeople need to recognise that their success depends on them being more “masters of heuristics” than “managers of algorithms” (Martin, 2009). Thus management needs to shift toward systemic and reflexive practices informed by design (Verganti et al., 2021) which require managers to experiment with different methods which contribute to the generation of “meta-skills and meta-thinking” (de Koning, 2019) in order to reconcile management with design and merge them into DM. According to the Design Management Institute (DMI), DM is “the art and science of empowering design to enhance collaboration and synergy between ‘design’ and ‘business’ to improve design effectiveness”. But, according to Borja de Mozota and Wolff (2019) DM is a “forced” interdisciplinary field, “a space between design science and management science”, but which “neither managers nor designers are truly interested in”.

In addition, DM should include the four theoretical dimensions which distinguish responsible innovation from non-responsible innovation in order to become DMfS. These four dimensions are reflexivity–“using dialogue to go beyond individual perspectives and jointly reflect on critical issues”, anticipation–“thinking in

a systemic way", inclusion–"involving a broader range of relevant stakeholders and collectively negotiating", and responsiveness–"considering emerging knowledge and insights and consequently adjusting the shape and direction of innovation" (Baldassare et al., 2024). As of now, the academic literature is still 90% focused on business issues and marginally on societal issues (40%) and environmental issues (7%).

In fact, management is incentivised by the shareholders, represented by the C-suite, to focus on profit. The existence of things as products or value propositions upon which the value creation process is based are conditioned by financial profit. Value is first and foremost financial and subsumes economic values. This can lead to conflicting values within organisations between the C-suite and the management. On one hand, most CEOs and CFOs insist on value for the shareholders. On the other hand, designers and product managers strive to become "better managers by design" (Borja de Mozota & Wolff, 2019) and aim to create plural values and blend them into desirable "value propositions" (Osterwalder & Pigneur, 2014) from a consumer or a user perspective. They use "business models" (Osterwalder & Pigneur, 2010) to convert the functional and symbolic values of the value proposition into economic value.

For DM researchers Borja de Mozota and Wolff (2019), a middle way between creating value for the C-suite and the management might be facilitated by designers if they were able to make their "silent design" and "silent management" skills explicit. Their skillset encompasses "the designer's ability to observe, coordinate, visualize, simplify, and make something coherent" by thinking with empathy for both the "user customer" and the "manager customer". Designers could use their cultural and social abilities to help reconcile the financial value with other values such as improving "well-being at work" and creating "a better world". A vision of a way forward, which is literally a way upward, has been proposed by the Danish Design Council as a metaphoric "design ladder". A similar metaphor is the DM "staircase" to be climbed towards innovation (new product), but not necessarily towards responsible innovation. To fill this sustainability gap the Centre for Universal Design of Australia has, for example, showcased a six-step ladder since 2019. The two upper steps are Design as Systemic Change–"a way of changing systems to solve complex social problems", and Design as Culture– "a way to innovate, a way to listen and a way to lead".

The DM staircase encompasses the three dimensions of product, service and organisations (as systems), but it usually does not care about the fourth dimension of how organisations interoperate responsibly with their environments. The novelty of the "Triple Bottom Line" approach (TBL or 3P–Profit, People and Planet) in the mid-1990s was to introduce profit-focused CEOs with "people" and "planet". According to Elkington, in 2018 and twenty five years after he had coined the TBL, major listed companies have hopelessly continued to strive to be "best in the world". Instead hope has come from B Corps which strive to be "best for the world". Although TBL has been integrated to various degrees into ESG, it has not yet achieved its goal of "system change" and has failed to alter "a hard-wired cultural problem in business, finance and markets" of unmitigated focus on profit targets.

If resilience is to be achieved in a highly volatile and uncertain context, the innovation process shall consider the life cycle of systems in which products and/or services are embedded (Fiksel, 2003). But resilient industrial processes alone are not enough and efficiency is still a key criteria in 5.0 framework (Ivanov, D. 2023). Achieving both resilience and efficiency requires a collaborative and flexible design process (Fiksel, 2003; Fiksel et al., 2015; Fiksel & Bakshi, 2023). But DM researchers often fail to consider product and service life cycles in a systemic way. Researchers have just recently started to produce design methodological tools for sustainable impacts. Their emerging proposals have not yet been sufficiently tested and challenged to be considered sturdy and consensual, neither in the design field nor in the management discipline. So decision makers can not rely on adaptable and collaborative methodological tools to be readily used in organisation to deliver performance and monitor it.

Our research approach

Can inherently complex social and environmental problems of sustainability be managed? The Cynefin framework (Snowden & Boone, 2007) addresses the issue of framing problems as either simple, complicated, complex, or chaotic. At both ends, simple and chaotic problems need acting first, but for opposite reasons. On one end, simple problems are clear cause-and-effect relationships, logically and mathematically well-defined and the system behaviour is well understood. They are "known knowns" which can be solved with management routines. At the other end, chaotic situations are unsolvable "unknowables" which need to be urgently ordered from chaos to complexity. A third class of problems–complicated problems–are defined as "known unknowns" which can be managed by experts through analysis and by applying good practice. But systems theory has unveiled a paradox: the better managed organisations, which are by definition the most adapted, are also the least adaptable. Thus what works best in a complicated situation turns out to perform worst in a complex environment.

Can “simplexity” (Berthoz. 2009) be achieved through reasonable simplification? Central to the Cynefin framework, complex problems are better managed by the interdiscipline of design. But “interdisciplinary communication works only if there is a real problem to be solved, and if the representatives from the various disciplines are more committed to solving the problem than to being academically correct” (Meadows, 2008). Such a commitment exists at the global level (cf. SDGs) and at the meso scale of DMfS cf. ESG).

In order to achieve sustainability in DM, we propose a two-step approach. First, a transversal analysis of how DM and DT have responded to the needs of Society 5.0 is based on a systematic literature review of proposed frameworks on DM and DT of fellow researchers Borja de Mozota & Wolff and Baldassare et al. In doing so, we concur with Lahire (2023) that the “scientific maturity” of our field of research implies that we do not necessarily have to produce first-hand data in our academic article. Thanks to the works we rely on, this article is “saturated with data” and hence should not be “(dis)qualified as theoretical”, but seen as a contribution to the structuring of the emergent field of DfMS. Borja de Mozota and Wolff’s article published in 2019 encompasses “Forty Years of Research in Design Management” between 1977 and 2017. This study is based on a list of 100 bibliographical references. We have narrowed our focus on the selected international literature between 2005 and 2017. Baldassare et al. (2024) explain that they have “systematically collected and critically analyzed the entire body of innovation management literature on design thinking”. Their corpus consists of a selection of 115 articles published in 42 journals between 2006 and 2022 “with a focus on identifying all mentions of the economic, social, and/or environmental impacts”. Their comparative analysis of the DT and responsible innovation approaches show that performance is the overwhelming issue of 90% of the articles, while “environmental and social impacts are clearly not yet an integral part of the design thinking equation” with respectively 7% and 40% of the selected articles. As a result, “infusing business ethics” into DT remains accessory.

Table 1. An overview of the academic literature on economic, social and environmental impacts in design management and innovation management

<table>
<tr><td rowspan="2"></td><td colspan="2">Evolution of DM (Borja de Mozota & Wolff, 2019)</td><td>Innovation management literature discussing the impact of DT (Baldassare et al., 2024)</td></tr>
<tr><td>2005-2014</td><td>2015-2017</td><td>2006-2022</td></tr>
<tr><td rowspan="2">Economic impact</td><td>Make companies aware of design strategy, Change for customer-oriented and creative culture, Changes in society, in politics</td><td>Digital transformation Strategic conversation value</td><td rowspan="2">90% of sample - an approach for businesses to gain competitive advantage through superior innovation performance, elaborating on implementation drivers and barriers</td></tr>
<tr><td colspan="2">Design methods, Design skills, DT, DM, DME Staircase</td></tr>
<tr><td rowspan="2">Social impact</td><td>Human value</td><td>Company sustainability in a globalized context of societal wellbeing, Cultural changes, Design for all</td><td rowspan="2">40% of sample - a user-centered approach that businesses, nonprofits, and governments can apply to improve people’s lives</td></tr>
<tr><td colspan="2">Holistic approach, Co-creation</td></tr>
</table>

Environmental impact	Eco-design	7% of sample - an approach to address pressing environmental issues, without elaborating on the nature of such issues, and providing limited evidence from real cases

More than 50 references are cited in this article. They were selected for their relevance with DMfS, for their importance in the two respective fields of research from which each of the two co-authors of this article have originated (i.e. management and design), and because of the insights they offer, the weak signals they identify and/or the methodologies and theories they propose. They have all been discussed and have helped to problematize our research endeavour.

In order to better understand the current, but still emergent, shift from DM to DMfS since the beginning of the 21st century and to better address the challenge of sustainability and also to account for the advance of sciences in all disciplines, we needed a guiding principle. The concept of “consilience”. forged by philosopher, scientist, historian of science William Whewell in 1840 has been a potent Ariane’s thread.

The fact that this concept had been seminal at the inception and for the development of the Darwinian natural sciences (Ruse, 1975) was not lost on biologist Edward O. Wilson. In his 1998 book *Consilience* he discussed the concept and called for the adoption of scientific methods and concepts developed in the natural sciences by researchers in the humanities and the social sciences (HSS). This approach of the biologization of social systems has become a classical feature of the interdisciplinary dialogue of the last thirty years or so. An original contribution to this ongoing conversation has been made by sociologist Lahire in his 2023 *The Fundamental Structures of Human Societies* in which he has proposed a more integrative study of “human social systems”. It is partly drawing on social theories influenced by the natural sciences, but it is also including key cultural inputs from the humanities. In this second approach, consilience between the natural and social sciences is viewed as a “sociologisation of the biological system” and stresses the difference between nature and culture.

A contribution to a vision of design management *for* sustainability

> *The common aim must be to expand resources and improve the quality of life for as many people as heedless population growth forces upon Earth, and do it with minimal prosthetic dependence. That, in essence, is the ethic of sustainable development. (Wilson, 1998)*

In a broad sense, the integration of design research and the study of the social processes in management is a form of DM consilience. Design research is inclined to study the products of culture (knowledge, know-how, artefacts) while management research is more focused on the study of social processes which impacts the organisations and are impacted by them. We will first address systems design as a DMfS approach influenced by the social sciences which are themselves informed by the natural sciences. Second, we will broach design thinging as an emergent DMfS approach inspired by the HSS.

Systems design informed by the natural sciences

A leitmotif of Wilson is that disciplinary boundaries within the natural sciences have been disappearing in the last decades of the 20th century. This holistic search to understand complex and multiscalar natural systems can be measured by the degree of consilience of the natural sciences as expressed by the principles of each division (evolutionary biology, ecology, organismic biology, cellular biology, molecular biology, biochemistry) that can be “telescoped into those of the others” without causing disorder. It has nurtured his belief in the unity of the sciences based on an orderly world which can be explained by the laws of physics. Thus even though complexity is what eventually interests scientists, the evolution of the natural sciences has been driven by Cartesian reductionism as the method to understand the real world.

"The love of complexity without reductionism makes art; the love of complexity with reductionism makes science".

In other words, holism has been the greatest obstacle to consilience by synthesis in the social sciences which by and large have not adopted "the metaphysical world view of consilience". Wilson believes that the natural sciences have shown the way as they have expanded their reach to "the borders" of the HSS. At this point, the boundary between the scientific and literary cultures should be thought of as an "unexplored terrain awaiting cooperative entry from both sides". Still, he reckons that applying consilience to the physical sciences has been "relatively easy", but applying it to the HSS will be "the ultimate challenge". One of "its severest test" is the question of how biology and culture interact in the context of "gene-culture coevolution" in which genetic evolution is much slower than cultural evolution.

At a social level, HSS have shown that "myth [...] and ritual, more than objective truth, gave [homo sapiens] the adaptive edge". At the individual level, empirical biological research has suggested that the brain is "a machine assembled not to understand itself, but to survive". The brain runs a "competitive selection" of scenarios in parallel. The winning scenario matches instinctive or learned favourable states according to the intensity of associated emotions. In other words, people make "satisficing" decisions (a Scottish term, that combines "satisfying" and "sufficing", that was introduced to psychology by Herbert Simon in 1957). But since decisions are triggered by emotional impact, they can be influenced by how well written and stimulating scenarios are.

For Wilson, the social scientists are "biophobic" and resist a vision sweeping "from society to neuron" similar to how biology has scientifically traced causation across many levels of organisation "from brain and ecosystem down to atom". One of the major reasons why "social theory is not yet true theory" is its "debilitating failure [...] to communicate with the natural sciences and even with one another". Hence it has not be tested against the claims of rival theories and according to the whole three-step process to test a theory: consilience by reduction "to dissect a phenomenon into its elements", consilience by synthesis "predictions, or educated guesses [...] to reconstitute it", and predictive syntheses "to predict with knowledge gained by reduction how nature assembled it in the first place".

Complex problems ask for systems design because they themselves are complex systems, part of larger complex systems. As Simon noticed "complex systems might be expected to be constructed in a hierarchy of levels, or in a boxes-within-boxes form". Complex systems can be represented as products and as processes. On one hand state descriptions (e.g. pictures, blueprints, diagrams) "characterize the world as sensed", on the other hand process descriptions (e.g. recipes, equations) "characterize the world as acted upon". In an artificial context, satisfactory designed artefacts are the products of designing construed as "means-ends analysis". In a natural environment, adaptive organisms are the products of a process defined as "the basic condition for [their] survival" or the Darwinian "survival of the fittest".

The main objective of Design for Sustainability (DfS) is the creation of resilient artefacts and it should logically be subject to the higher-level goal of producing these artefacts in a resilient manner for both the society and the natural ecosystem. For designer Sevaldson (2013) systems thinking is "an interdisciplinary science" closely related to ecology . Modern ecological thinking does not separate human activity from the natural but looks at the whole interaction of man with nature. Therefore ecology also touches upon economic, technological and even sociological issues. Looking at design projects as "organisms" living in "ecologies" changes the mindset towards systems thinking applied to DfS and paves the way for systems design.

> *The most stunning thing living systems and some social systems can do is to change themselves utterly by creating whole new structures and behaviors. In biological systems, that power is called evolution. In human economies, it's called technological advance or social revolution. In systems lingo, it's called self-organization. […] the ability to self-organize is the strongest form of system resilience. A system that can evolve can survive almost any change by changing itself. (Meadows, 2008)*

The main purpose of DMfS is to design resilient processes. For that purpose, the concept of hierarchy is key and has a different meaning in systems thinking and in management. Even though DM recognizes the possibility of "a vision of non-hierarchical design leadership based on the radical humanist paradigm" this critical approach is not mainstream in DM (Borja de Mozota & Wolff, 2019). Meadows' definition and emphasis on the principle of hierarchy as an "arrangement of systems and subsystems" is similar to Simon's "boxes-within-boxes". She has added that hierarchy is "healthy" under the three conditions of dynamic stability, communication efficiency and resilience. First, system stability is optimal "when no subsystem's goals dominate at the expense of the total system's goals". Second, bottom-up self-organisation is efficient as it reduces the amount of information that any part of the system has to keep track of. Third, evolution "from simple systems [to] complex systems" allows resilience–"a big plateau" or what Simon referred to as *homeostasis*.

How does DMfS theory apply in real world cases? In 2021, complexity theoreticians Sellberg et al. answered a "heightened interest in managing for resilience" and proposed a study of twelve cases. They wrote accounts of each situation being addressed as a "social-ecological system's capacity". Their work is an attempt to conceptualise social-ecological interactions and assess system dynamics and strategies to facilitate dialogue between actors. The authors admit that their three-step design methodology is a work-in-progress and can not yet be construed as a blueprint. They have proposed a three-step flexible and iterative process as a sequence of assessing, thinking and designing which adds value to Meadow's approach by trying to explicit her implicit management principles.

Design thinging inspired by the humanities and social sciences

Designing epitomises human activities for humans *by* humans, and increasingly *with* humans. The history of design reflects an evolution *from* good design of things (Papanek, 1976), *through* good design practices *to* designing for good. The dramatic design thinking shift of the 2000s—from products to users—was sudden and the ability of designers to balance this new skill with ethics is questionable. Designers tend to adopt utilitarian ethnographically-inspired techniques in order to interpret users' needs. But user-centric design shows little of "the reflexivity of the social science traditions" (Kimbell, 2011). Business anthropologist Miller (2014) points out that design has only recently engendered self-reflection which "have converged to raise environmental issues and rampant consumerism as serious concerns". The narrow focus of DT on user-centricity can no longer suffice. DT needs to become critical as it encompasses environmental and social issues.

Critical design and Latour's Actor-Network Theory (ANT) are situated and grounded. ANT challenges Simon's view that there is no science of the particular and claims that "contrary to the scholastic proverb, there is science only in the particular". Still, Latour (2010) has proposed that closure be achieved by "the slow process of composition and compromise". Thing as thinginess (Heidegger, 1968) is a quasi-judiciary assembly—a *gathering* dealing with "an issue very much in there". Latour recognises the ambiguity of a "*thing* [which] designates matters of fact and matters of concern", but insist that the social reality can only be reassembled by a critical approach of matters of concern. This interdisciplinary process between the HSS (anthropology, philosophy, metaphysics, history) can be facilitated by design as a critical interdiscipline or an "indiscipline" (Gentès, 2017).

"Artificial things" were defined by Simon as "interfaces" between an inner and an outer environment. These things (e.g. boundary objects) are designed to provide the conditions for the participants to gather, to discuss problems, to reflect on their behaviours. Hence design thinging is hic et nunc participatory design. From an ANT perspective, it provides a specific account which "will *perform* the social" and "gives it a form" (Latour, 2005). Science studies and semiotics have shown that texts are not "just" stories, "only" narratives or "just like fiction". Instead, an account is a text that obtains truth and objectivity "either by an objectivist style […] or by the presence of many *objectors*". A good account can also be a graphic form that "*traces a network*" (Latour, 2005).

Meadows also emphasised the importance of representations and admitted to having made "a liberal use of diagrams and time graphs" in her book. Because systems "happen all at once", they are connected in many directions simultaneously. The more participants draw structural diagrams and write equations, the faster they will admit their uncertainties and correct their mistakes, and the more flexible they will be. Latour's and Meadows' approaches can not be reduced to McLuhan aphorism "the medium is the message", but they nonetheless stress the utmost importance of the cultural forms of thinging. It has been an emerging concept since the 2010s and has migrated from Heideggerian philosophy into at least three disciplinary fields related to design: computer modelling, participatory design and material engagement theory. Because the focus of our discussion is on HSS, we will not broach further than Al-Fedaghi (2018), for whom computer science engineers have to view a system as a whole in order to design a complex software system. The complexity of software design development has to be mitigated by "a simple representation" to facilitate the communication of requirements between business and information technology professionals who are designing "things that happen" in a boxes-within-boxes activity by which "thinging machines" populate a world that is itself a thing-machine (Al-Fedaghi, 2019).

On their emergent interpretations since the 2010s and 2020s in social design and in the humanity discipline of cognitive archaeology, even though participatory design and the material engagement theory are ignoring each other.

Björgvinsson, Pelle and Hillgren (2012) and Zuljevic, Roosen and Huybrechts (2023) refer to "design things" as the products of a social design process. Inspired by ANT, it is integrating non-humans. This participatory design encompasses projecting as "use before actual use" and infrastructuring as "design after design". Design outcomes are considered as "socio-material frames for controversies". Things are

not mere systems descriptions, they are ”engaging hands-on design devices” (i.e. “boundary objects”, e.g. mock-ups, prototypes, design games, simulations). The participatory design process entails “democracy and legitimate participation” and infrastructuring. Things are created as socio-material assemblies or self-organisations, and these systems interact with the environment in ecosystems.

In cognitive archaeology, the material engagement theory is “the radical embodied cognitive science that aims to integrate the whole system ‘brain–body-landscape of affordances’”. At the individual level, creative thinging depends on metaplasticity (i.e. “the plasticity of the brain [...] inextricably intertwined with the plasticity of culture” and the ability to think and feel “with, through and about material things”). At the social level, thinging is a “cognitive ecology” (i.e. a “shared interiority among a variety of human and non-human forms”). At both levels and between them, thinging is interactive and goes beyond “a process by which the mind imposes forms on matter” (Malafouris, 2014 & 2020; Mosley, 2021).

Sociologist Lahire regrets that the social sciences in their current state are “pre-Newtonian” or “pre-Keplerian”. The theories which have been formulated in the HSS do not have the status of theories as laws or common paradigmatic frameworks. Disciplinary “border control” has disqualified transdisciplinary rapprochements between the social sciences and the natural sciences. Instead, consilience requires the application of four principles. First, “humans are animals amongst others”. Second, from an evolutionary perspective culture is a more efficient and adaptative solution to the changing environment than genetic natural selection, and “the human species is cultural by nature”. The third principle is “the co-evolution of gene-culture or of organism-environment” (The failures of the so-called “memetic” science” and of evolutionary psychology for instance have shown that the Darwinian theory can not be strictly applied to human history, but needs to be adapted (Edmonds, 2005; Fog, 1997; Dawkins, 2016). The fourth principle is that “biological properties are the framework of social relationships”. The goal of this approach is to propose a paradigm in order to study “the human social system”.

Even within the HSS, the social and the cultural (knowledge, know-hows, artefacts) are too often synonymous. But animal species do not have a cultural life. Still ethologists have described the common structures of their social lives. The social sciences have not paid attention and have missed the opportunity to propose “a trans-contextual logic” or “evolutive analogies” shared by humans and non-humans even though it has been proved that “similar solutions emerge independently from each other in order to answer the same adaptive challenges”. The HSS have been plagued by “hyperspecialization” and the researchers’ “corporatism” has cut them off from the big existential issues of the origin and the future of humanity.

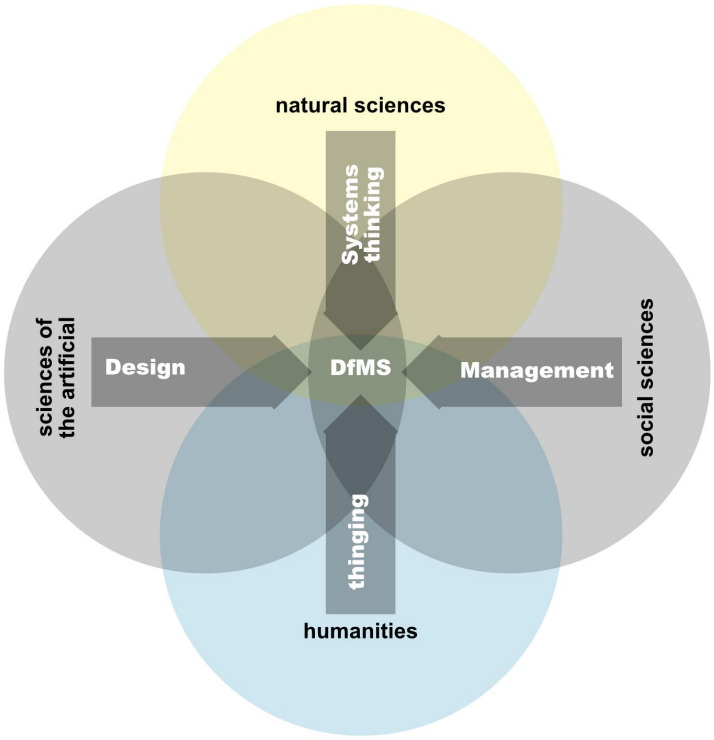
A consilient framework of interdisciplinary contributions to design management for *sustainability*

A key take-away for managers is inspired by Meadow’s quote (2008) that “systems can’t be controlled, but they can be designed and redesigned […] we can dance with them!”. Improvisation and free style demand that participants have acquired the required skills, have adopted the right mindset, and are allowed the necessary leeway. The analogy with the performing arts is not random. It is linked to the cultural concept of thinging.

Designers have a key role to play in representing systems thinking and giving a form to things. These representations rely more on drawing (“*dessin*” or sketching in design than writing. It paves the way for the performative dimension of the design process, i.e. “*dessein*” or design by purpose for Vial (2015)). “Infrastructuring” or “staging” things-as-socio-material frames for controversies (design-by-playing) is, in turn, “opening up new ways of thinking [...] the possibility of design-after-design”. These things in use help “transform antagonism [conflict between enemies] into agonism [constructive controversies among ‘adversaries’]” (Bjögvinsson, Ehn, & Hillgren, 2012).

For the sake of clarity and as an effort to popularise our research endeavour, we propose a synthetic representation of the DMfs framework (cf. Figure 1). The horizontal axis is inspired by the figure of “The Two Forces of Design Management” (Borja de Mozota & Wolff, 2019) in which DM is sketched as the intersection of the force of Design in management (Dm) and the force of Management toward design (Md): Dm⇨DM⇦Md. The vertical axis represents sustainability at the convergence of the human societal thinging of things (Tt) and of the environmental systems thinking (St) of the natural sciences: Tt⇨S⇦St. DMfS sits at the crossing of the horizontal and vertical axis.

Figure 1. The consilient DMfS framework



Concluding remarks

The transformative vision of Society 5.0 is framed by the SDGs framework at the meta level, and rests on how our individual relationship with the environment can be reshaped at the micro level. At the meso level, it also depends on the development of tools, skills and competencies as well as a mindset shift leading decision makers to climate and societal action, in addition to creating value.

Despite an emerging trend in both the academic and professional communities to acknowledge the importance of DMfS, the DM and DT literature has still been overwhelmed by linear approaches and a focus on short-term financial profit. Systems design and design thinging, which have respectively originated in the natural sciences and the humanities, offer wider perspectives. They can converge through interdisciplinarity and help expand the existing DM mix of social sciences and sciences of the artificial to change its focus through the natural sciences and the humanities towards sustainability by design; i.e. DMfS. In this perspective, our contribution to DM research revolves around a two-pronged proposal and a consilient academic approach to frame a much needed theory of DMfS (cf. Figure 1).

Articles presenting action research have been identified and discussed in this work. At this budding stage of DfMS, there are not enough of them to infer and identify structured and structuring patterns and protocols and to test their validity. Hence the validity of the first experimental results can not be generalised or scaled and the theoretical proposals should be consolidated. Our call-to-action goes in two directions. On one hand, academics should conduct and publish more action research by developing experimental designs. On the other hand, academics should team up and/or strive to be embedded in innovative organisations in which original DMfS set-ups have been experimented and sometimes deployed. In turn, the impact of such processes and methodological tools should be assessed and hopefully be generalised in practice. The DfMS theoretical framework we propose is no exception. It should be tested in organisations by professionals and with the help of researchers. Its impact to empower managers and designers to frame things and systems in order to meet ESR requirements by design and to help organisations do their part to achieve the SDGs should be evaluated.

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Appendix

Table 2. The four levels of sustainable design

Sustainable design theory (Baldassare et al., 2020 - academic literature)	Conditions to Innovate through Responsible Design Thinking (Baldassare et al., 2024).	Design purpose (Baldassare et al., 2020 - design perspective)	"Strategic objective of sustainable design [...] from a business practice perspective" (Baldassare et al., 2020 - experts' inerviews)	Design Management staircase model (Baldassare et al., 2020)

Ecodesign: “strategies, methods and tools for developing sustainable products”	The micro level of “sustainable entrepreneurs”	Innovation and feasibility (use-before-use and design in project) [Tool and method] product life cycle “results in a redesigned product with a life cycle that has a lower environmental impact”	Profit** “think beyond the ‘form and function’ of their product, changing its life cycle”	Project “Product design is typically a task of the R&D department, where designers, engineers and in some cases scientists collaborate. [...] at this level, the perspective of designers is department centric.[...] they use an engineering terminology.” “Implementing services around sustainable products requires the involvement of the operation and logistic functions [and] multilateral cooperation with external partners beyond just suppliers and ultimately users as well play an active role”
Product service system design: “design as a strategic competenc e [...] to develop a mix of tangible products and intangible services” “customers pay for using a product instead of buying it”		Customer centricity (use-before-use and design in project) [Tool and method] product as a service “fulfilling final customer needs while fostering a positive sustainability impact” “For businesses, [...] to enhance competitivenes s and foster sustainability” “From a sustainability perspective, [...] lead to enhanced efficiency in use and product longevity”	Profit** and People “think beyond the life cycle of its product”	

Sustainable business model design " to develop new ways of doing business integrating sustainability into the objectives and operations of organizations"	The meso "strategic level in the organization " to "address environmental and social challenges, [...] jointly shaping the value creation process, while also reconsidering the notion of value itself"	Inclusivity; e.g. users, customers, human and non-human stakeholders (design things in use) [Tool and method] Circular Economy "results in a (new) organization driven by a social and environmental purpose" "Design is a central aspect of sustainable business model innovation. The word design is mentioned repeatedly" "designers are especially well suited [...] to connect human needs and dreams with new opportunities and inspirations from science, technology, and business."	Profit** and People "think beyond products and services, (re)defining its purpose, how it functions from an economic and operational standpoint"	Function "requires the commitment of the upper management and the CEO

Collaborative ecosystem design: “how to develop new interactions across firms in order to reshape entire markets and industries toward a sustainability transition” “wider industries and markets”	Economic sectors (macro level) and Ethical approaches (meta level) “address wicked problems, and catalyze the action of organizations around seventeen specific sustainable development goals, such as climate action, but also the elimination of poverty” (UN, 2015) “connections may be established with literature on sustainable innovation, corporate social responsibility, or circular innovation”	Contextualisation: critical design of eco-self-organisation (design-after-design) [Tool and method] “a collective conversation of all the parties involved” “the term ecosystem” “ collaborations as macro business models in which multiple organizations jointly deliver a value proposition [...] beyond a firm centric approach” “results in a coalition of organizations collaborating to drive the sustainable transformation of an economic sector”	Profit**, People and Planet “broadening the scope beyond single business models in order to transform the entire socio-technical system, entire industries and/or market sectors through a collective conversation of all the parties involved”	Culture “the representatives of each business, often at the upper management level [...] legal experts are also needed [...] and also public officers, who can drive top-down change, and civil society, who can drive bottom-up change”