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Systemic design reasoning for societal transitions

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Abstract: one of the emergent approaches towards designing (for) transitions and transformations is systemic design. Systemic design is an emerging field which integrates systems theories and practices with design theories and practices to address complex societal challenges. We distinguish two dominant perspectives and associate practices: using systemic visualisations as a sense-making tool of complex challenges, and 'designing from within' through collective designing by system stakeholders. In this paper we introduce a third perspective and practice that we call 'systemic design reasoning'. This perspective combines the abductive reasoning logic of design with various systems theories and practices to develop 'systemic design rationales'. We developed systemic design principles to support this reasoning practice, each based on a specific systems theory and practice. We illustrate the principles with examples of their application in research and in education. We conclude with a research agenda to further the practice of systemic design reasoning for societal transitions.

Keywords: transitions; systemic design; design reasoning; design principles

1. Introduction

Systemic design is one of the interdisciplines that addresses design's role in transformative change in the pursuit of sustainable, just and resilient futures. While transition design, transformation design and systemic design are often framed as separate sub fields of design, they also share many societal and academic objectives and underlying theories and practices of systems thinking and complexity. In this paper we will argue that the systemic design practice of 'systemic design reasoning' is an essential practice for systems change and therefore a key characteristic of design's role in transformative change.

Systemic design is an emergent field which studies the integration of systems theories and practices with design theories and practices to address complex societal challenges. Systemic design takes a pluralistic approach to systems thinking and is not tied to one

specific theory or practice (Sevaldson and Jones, 2019). Systemic design differs from technical systems design or systems engineering, as the complex systems that are designed for, or with, cannot be objectively defined and have properties that cannot be fully predicted. The UK Design council (2021) distinguishes two types of systemic design: system-conscious design and system-shifting design. In system-conscious design, what is designed is a product or service with the intention to produce a certain function, taking into account its potential side-effects on a larger subjectively defined system, e.g. communities, society, economy and the environment. Where system-conscious design is aimed at designing products and services without adverse systemic effects, system-shifting design has a radically different intention, namely to shift systems into a desired direction, for example designing for the protein shift to develop a more sustainable food system, or shifting the academic system to improve wellbeing of students and staff. Designing for transformations and transitions fits within this system-shifting perspective. Similar to transition design, system-shifting design is based on the belief that socio-technical systems can be deliberately changed by developing a long term shared vision representing a system 'directionality', that co-evolves with a portfolio of interventions or experiments that are aimed at both creating change and at 'learning our way forward' (van der Bijl-Brouwer, Kligyte, & Key, 2021).

Reviewing systemic design literature, we can distinguish two dominant categories of practices. The first category is aimed at making sense of complex contexts by generating systemic visualisations. Those visualisations are typically based on a variety of systems theories and practices, such as causal loop diagrams, system structure iceberg model, and social network analysis (see Jones and Van Ael, 2022). Systemic visualisations are used as a sense-making tool and as inspiration for a design process. A second category of practices is aimed at 'designing from within', perceiving (service) systems as being continuously designed and redesigned from the inside out by system stakeholders (see Vink et al, 2021). This collective designing is supported by a meta-level design process, referred to as 'infrastructuring' (Björgvinsson, Ehn, & Hillgren, 2012) or 'staging' design (Vink et al, 2021).

In this paper we focus on a third practice which we define as 'systemic design reasoning' and which complements the systemic visualisation and design from within practices. Systemic design reasoning combines a pluralistic perspective on systems change, with expert design reasoning practices. We believe that the abductive reasoning practice of design can be supported by various systems theories and practices to develop 'systemic design rationales', which support the design of systemic interventions. The objective of our research is to investigate how systemic design reasoning practices enable designing for transitions and transformations.

In the next sections we will first elaborate on the concept of systemic design reasoning and argue how 'systemic design principles' support that reasoning process. We present five systemic design principles, each based on a specific systems theory and practice. We illustrate the principles with examples of their application in research and in education. We conclude with a research agenda to further the practice of systemic design reasoning.

2. Systemic design reasoning

2.1 Design reasoning

Design reasoning is a practice performed by professional designers and (social) innovation practitioners. Designing has been considered to include distinct reasoning patterns since the 1980s when design was established as a coherent discipline of study, and scholars started to refer to this reasoning process as a designerly way of knowing (Cross, 1982). In this paper we will draw on the work of Dorst who, building on Schön's theory of reflective practice (Schön, 1983), has shown in empirical studies how designers reason (Dorst & Cross, 2001). In particular, we apply Dorst's logical framework for abductive design reasoning (Dorst, 2011).

In this logical framework, Dorst (2011) explains how reasoning in design constitutes of a *what* and a *how* that together lead to aspired *value* (Figure 1). The how in this logic is a working principle or mechanism (how) that explains how a certain designed proposal or prototype (what) leads to a certain desired outcome (value). We refer to this logic as the *design rationale*, the representation of reasoning behind the design of an artefact (Knudsen, 2020). Dorst (2011) explains how at the start of a design process we only know the end value we want to achieve. The challenge is to figure out *what* to create while there is no known mechanism (how) that we can trust to lead to the aspired value. Design reasoning includes deliberate strategies to tackle the complex creative challenge of coming up with both a thing and a mechanism that are linked to the attainment of a specific value. This reasoning is supported by adopting various frames. "A frame is the general implication that by applying a certain working principle we will create a specific value" (ibid, p524). An example mentioned by Dorst is the reframe of a problem situation in an entertainment district from a 'law and order' frame to a 'music festival' frame. In the music festival frame, the aspired value is 'young people wanting to have a good time' and the associated working principles of the music festival include for example crowd control and wayfinding (ibid). Studies of the reasoning patterns of expert product designers show that framing happens in a process of co-evolution between frame and solution (Dorst & Cross, 2001).

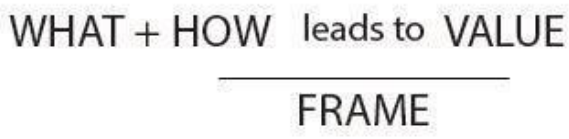

Figure 1 A design rationale presents a design (what) and its accompanying frame: how the design is assumed to lead to certain value (adopted from Dorst, 2011)

2.2 Design reasoning towards systemic value

When we consider the outcome of a design reasoning process, this outcome is often framed around value on a human or stakeholder level. Developing mechanisms for impact on a human level can be supported by various 'drivers' such as academic research from psychology or sociology, metaphors and analogies, design research, and provocative

prototypes (van der Bijl-Brouwer, 2019). In addition, designers may also use design principles or 'guiding principles' (Lawson, 2006, p159) which are derived inductively from extensive experience and/or empirical evidence, and which provides design process guidance to increase the chance of reaching a successful solution. While design principles are generally applicable and abstract, a mechanism is contextualised and specific to a particular design.

When we address complex societal challenges and want to design for longer term transitions and transformations, the outcome of whatever we are designing shifts from short term value for individual stakeholders to longer term 'systemic value' or 'transition goals'. Systemic value we here define as contributing to a desired system shift and as value that goes beyond value for individual stakeholders to society more broadly.

Systemic design reasoning then is a process in which the challenge is framed both on a personal or human level and a larger systems level, and in which the working mechanism includes a systemic mechanism and a contextualised mechanism, emphasising the individual human experience, need, behaviour, or relationship.

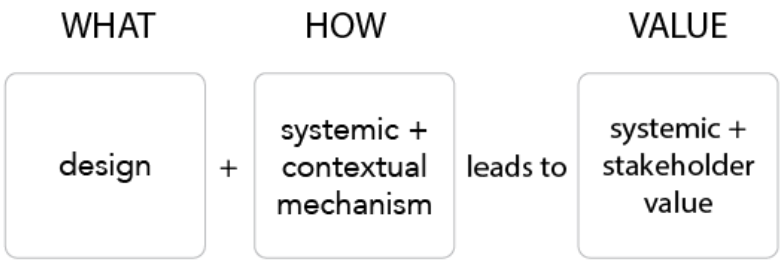

Figure 2 Systemic design reasoning is the practice of working towards a design rationale aimed at both systemic value and individual stakeholder value

However, working with mechanisms for systems change is not common amongst design practitioners. If we want to enable systemic change, then what are design principles to work towards these systemic outcomes? Systems change principles are often based on the idea of 'leverage points', places within a complex system where a small shift in one thing can produce big changes in everything. Meadows (1999) identified twelve of these leverage points, ranging for example from increasing leverage from parameters (such as subsidies), to information flows, to system goals, to mental models and paradigms out of which systems emerge.

Systemic design reasoning is thus aimed at linking a systemic and human mechanism to both systemic and stakeholder outcomes. Like any other design reasoning process this is not a linear process, but involves co-evolution of problem and solution. Designers need to judge which systemic design principle is relevant to the transition they are contributing to, and they need to creatively combine systemic design principles with mechanisms on a human

level. In our research, we have found that such design principles for systems change can be based on a variety of systems theories.

It should be noted here that the concept of 'systemic design reasoning' that we coin in this paper, is a specific type of design reasoning, and is not to be confused with the more general concept of 'systems reasoning', the foundational logic of systems theory and practice, which includes for example synthetic thinking (understanding of a phenomenon within the context of a larger whole, for example Ackoff, 1999) and observing feedback loops or circles of causality (for example Senge, 1990). To illustrate the concept of systemic design reasoning we present five systemic design principles in the next section that can be used in a design reasoning process to develop mechanisms for systemic value, in other words a systemic design rationale.

3. Systemic design principles to develop systemic design rationales

Within our research lab we are developing a range of systemic design principles that are aimed at developing systemic design rationales. In the context of design, we consider a principle as a rule or heuristic established through experience that guides a practitioner towards a successful solution (van der Bijl-Brouwer & Malcolm, 2020), also referred to as 'guiding principles' (Lawson, 2006). Principles are context-dependent, but can be applied across similar design contexts. Examples of design principles for the emerging systemic design field include those proposed by Jones (2014) such as boundary framing, requisite variety, generative emergence, and continuous adaptation. While Jones' (ibid) systemic design principles are 'foundational' and aimed at generally improving the practice of systemic design, the principles we present here are each specifically aimed at providing input to develop systemic design rationales in a design reasoning process.

The principles were developed based on a combination of systems theory literature and either 1) action research, iteratively applying and evaluating the principles, or 2) descriptive case study research of social innovation cases in practice (van der Bijl-Brouwer & Malcolm, 2020). The principles were applied and explored in various research projects and in education. We highlight five of these principles in this article to illustrate how they can be used in a systemic design reasoning process.

3.1 Systemic design principle 1: Social contagion

The systemic design principle of social contagion is based on the fact that a person's behaviour is influenced by social interactions with others, contexts, and the norms these ensue (Christakis and Fowler, 2013). In decision making, people have the tendency to use this as a shortcut to reduce their effort in decision making - assuming others have more knowledge, or that the majority must be right (Centola, 2018). However, this influence can be a double-edged sword. On the one hand, it brings people and cultures together, it facilitates the exchange of information and resources. On the other hand, it can be easily exploited to spread misinformation and exert pressure on individuals to engage in negative behaviours like smoking or violence. The effects of social contagion (both negative and

positive) can be observed to understand dynamics in social networks but also used to understand how change runs through a network. Considering transformative change and the interplay between the individual level and the systemic value, this principle can offer guidance. An important note is that this principle should not be understood as design for manipulation, but for design reasoning with deep system understanding and advocating transparency.

Design reasoning for social contagion includes answering the questions: what social networks are in the system? What information is shared in these networks? What causes (dis)trust in the networks? The field of social network theories offers different useful theories and concepts (Gamper, 2022), such as the concept of strong (family, close friends) and weak ties (acquaintances); the concept of homophily, that explains how people tend to align one's choice with those of similar others; and the concept of popularity, where some actors have more relationships than others or have a stronger influence in their relationships because of a certain status. The mechanism in a social contagion rationale should include the understanding of the means for "how" behaviour spreads, the networks in which the behaviour can unfold, the incentives and reciprocity for the behaviour, as well as the starting points of the contagion. The anticipated outcome or value should be clear on both an individual and system level: "what" behaviour will spread and what effect does this have when large groups adopt this new behaviour?

An example comes from a study within the context of the energy transition in the Netherlands. In the Netherlands municipalities are tasked with executing energy transition plans and mobilising their citizens. To reach and incentives all citizens individually is too costly and time consuming. Also, it was found that among social housing residents mostly negative stories go round and few positive stories are known. Therefore, among other things, a chain letter was designed where it was incentivized to share positive and inspirational stories from one individual to another in a neighbourhood.

3.2 Systemic design principle 2: Resilience

According to Taleb (2007), our world is ruled by Black Swans or surprising events which have a major impact and are often inappropriately rationalised after the fact with the benefit of hindsight. Although defined as rare, the frequency of these Black Swans seems to increase alarmingly. Just think about the COVID-19 pandemic, the Suez Canal obstruction, and the current Israeli-Palestinian conflict. As more Black Swans are looming, a need for resilience, and this principle, arises. Following Nieuwborg et al. (2023), resilience is approached as an overarching concept that can be dissected into four aspects: fragility, robustness, adaptation, and transformation. Depending on the aspired aspects, multiple systemic working principles can be used to diagnose, create or increase resilience.

Table 1 Design rationale to design for social contagion in relation to the energy transition for social housing in the Netherlands

What	How (assumed mechanism)	Value (assumed outcome)
Chain letter with positive stories	Human mechanism: people are more likely to copy decisions/behaviour from others similar to them Systemic mechanism: by reaching one person (starting point for the chain letter) you are able to reach many more	Human level: a citizen is encouraged towards taking action for the energy transition by receiving inspiring stories from neighbours Systems level: every time the chain letter is forwarded the collection of positive stories grows, and when more people have changed the more likely it is even more people will change

Design towards resilience requires us to answer the following questions: what system should be resilient, and what are its boundaries? Against what Black Swan or other stressor should the system be resilient? How would the system react to this Black Swan? What parts of the system will be fragile, robust, adaptive, or transformative? What are the desired states of these parts? Should they be fragile, robust, adaptive, or transformative? How can we design towards these desired states? This principle proposes a two-step approach consisting of a problem definition and the design process. As resilience can become a buzzword-like concept (Hillmann & Guenther, 2021), rigorous problem definition is required regarding the complex system, the looming Black Swan, and the desired aspect of resilience. Then, the resilience design process can commence, drawing inspiration from a wide array of resilience strategies (Ramezani & Camarinha-Matos, 2020). The mechanism in the rationale should include the means to design for the desired resilience aspect. Who the desired aspects define is highly context-specific as it could be parts (i.e. stakeholders) or the complex system as a whole.The outcome consists of the anticipated impact on the individual in terms of created resilience, which can then trickle down to the systems level. It is important to note that resilience is a highly contextual concept. For example, a system can be robust against heavy rainfall but extremely fragile against droughts. Subsequently, achieving resilience is a continuous process without an end state, hence design towards resilience.

To illustrate, we use the example of Tseitlin (2013) regarding chaos engineering in Netflix. Although the case utilises other jargon, under the hood, there are multiple commonalities to the design towards resilience principle. To increase the resilience of Netflix's network and services, the company introduced the practice of chaos engineering. Chaos engineering aims to improve Netflix's network by purposefully inducing failures into their day-to-day operations, for example, shutting down data centres randomly, which they call "Chaos Kong". Their underlying philosophy is that as failure is inevitable, it is better to self-induce it and then proactively learn about one's mistakes, emphasising the transformative aspect of resilience. This contrasts sharply with traditional practices, focussing on theoretical simulation and analysis, which can be regarded as robust. Note that Chaos Kong requires strong ethical oversight, and the emphasis should be on learning.

Table 2 Design rationale to design towards resilience in relation to Netflix's ambition to create a resilient network

What	How (assumed mechanism)	Value (assumed outcome)
Chaos Kong	Human mechanism: chaos engineering self-induces failures into the day-to-day operations of systems Systemic mechanism: increasing the resilience of a system by proactively challenging the system	Human level: Netflix's engineers are able to proactively experience failure making thus training them for future crisis Systems level: collectively the engineers take action within Netflix's system to continuously improve its resilience

3.3 Systemic design principle 3: Emergent social networks

When designing for systemic change, it is essential to understand the interconnectedness of the actors of a system (Murphy & Jones, 2021). A social network is never stable as there is a constant flow of actors and interactions. When talking about emergent social networks this dynamism should be taken into account. The aim is to create a "healthier" network that functions better to serve a certain purpose. The anticipated outcome could for instance be enhancing collaboration between different stakeholders, creating sub-communities, or weakening an over-dominant part of the network.

Social network analysis (SNA) investigates social structures by making use of network and graph theories (Zhang, 2010). The aim is to reveal hidden patterns that are created through the interactions between actors in a system. While in network science SNA is associated with large data sets that typically focus on a single type of relationships, designers tend to follow a more qualitative approach and dive deeper into interaction patterns in order to use them as leverage points (Ahrens, 2018). For instance, studying the patterns of communication could help designers understand the collaboration dynamics between different stakeholder groups, while giving clues on which stakeholders are more influential and why.

Understanding how the actors in a system interact informs designers on the behaviour of individuals or communities. However, human relationships are typically multi-layered, as actors can be tied to each other in multiple ways (a common example is people who are friends and coworkers at the same time). These different relationship natures form different networks within the same group of actors (Hanneman & Riddle, 2005). Hence, social network analysis gives an overview of opportunities or threats that result from systemic interdependencies. While these interdependencies help reasoning complex social constructs such as trust, they also give clues on favourable network conditions that help designing interventions towards a prosperous system. This way, SNA can show the opportunities for interventions to steer the network towards the desired direction (Murphy & Jones, 2020). Some examples of the kind of change design interventions on social networks can cause are:

- changing the frequency or intensity of existing interactions within a network

- introducing new types of relationships to the network
- dismantling social constructs with negative association such as polarisation
- creating conditions for the emergence of positive dynamics such as trust or alignment

An illustrative example showcasing the transformative impact of optimising social networks on generating system-level value emerges from the northern Netherlands. In this region, the local innovation ecosystem was characterised by a pronounced hierarchy with recurrent connections, stifling the growth of smaller initiatives. Recognizing the need to reshape network dynamics favourably, the local government implemented a diversity rule in local tech grants. This rule encouraged consortia to assemble teams that embraced diversity in terms of experience, background, and gender. Consequently, the network experienced inclusive expansion, dismantling the detrimental dominance of multinational entities over time.

Table 3 Design rationale for social network driven approaches when establishing a fruitful innovation ecosystem

What	**How (assumed working principle)**	**Value (assumed outcome)**
Rule of diversity in local tech grants: prioritising team diversity for gender, seniority and background	Human mechanism: creative processes are enhanced with the collaboration of diverse individuals that form the social network Systemic mechanism: if the stakeholders are encouraged to involve diverse partners in their projects on the grant proposal phase, local creative network will slowly but surely diversify and new relationships will emerge through unexpected partnerships	Human level: bringing new perspectives with diverse projects partners contributes to creativity and critical thinking that are essential to innovate Systems level: active involvement of genders, backgrounds and generations exposes the ecosystem to different perspectives and expertise, ensuring the rapid democratisation of the ecosystem by disrupting the domination of highly-influential local social groups

3.4 Systemic design principle 4: Friction

This principle puts forward the notion of tension or friction as a fruitful focus for systemic design. The basic idea is that large-scale change unavoidably implies friction due to conflicting values - within people, between stakeholders, between sectors or even between generations. Such frictions -when they arise- are often framed as problems: something we need to remove and resolve. From a design perspective however, they are often considered as interesting starting points for meaningful innovation and systemic change.

In design reasoning, designers are known to employ integrative thinking to trigger the development of creative resolution for seemingly opposing stances (Ryan, 2014). This integrative thinking, or ‘dilemma-thinking’ (Ozkaramanli, 2019), is valuable in the light of

social dilemmas where personal value and public value conflicts (Tromp & Hekkert, 2019) or multi-stakeholder dilemmas where stakeholders have opposing values (Ozkaramanli, 2021). The direct reasoning pathway is to seek ways to respond to the conflict in values, e.g., to resolve, bypass, or transform the conflict through innovation (Tromp & Hekkert, 2019). In this case, the designer seeks a way to respond to one of the conflicting values or address other values that are more important to people to shift behaviours. Why is the change so difficult to engage in for the stakeholder, what values are at stake? Can we address that value, make societal value more personal by making it experiential for a stakeholder, or can we consider other prominent values of stakeholders to tie our solution into to foster change? The indirect reasoning pathway is to explore how to "reconstitute the whole system to open up new possibilities for transformation" (Burns, 2011). In this form of reasoning, the designer seeks to detect the system characteristics through which the conflict emerges. Why is the current system so dominant in positioning stakeholders as they are positioned? What systemic mechanisms are determining stakeholders' positions and can we change those? While direct reasoning pathways seek individual intervention with systemic effects, indirect reasoning pathways seek systemic intervention with systemic effects (Sturms & Gadlin, 2007).

An example that illustrates well this role of friction and conflicting values in design is the project of Serrarens (2015) called Loop. Loop is a platform for purchasing consumer goods. But rather than paying with money, here you pay in resources. Once you are seduced to buy a product, the website guides you to the back-end of the product and explains the growing or mining of resources, the production principles and regions and the variability in produce due to weather circumstances, and the designer and its business - explaining the actual costs of a product in terms of time and resources. The chair you really want to have can be grown in three months if it is made of flax, but if you prefer a teak chair, you have to spend your expensive resources or wait a few years. The platform induces friction in consumption, but through that, sustainability becomes an internalised concern for people - they now experience the consequences of their consumption behaviours.

Table 4 Design rationale for Loop based on the friction principle

What	How (assumed mechanism)	Value (assumed outcome)
Loop, i.e., resource-based consumption webshop	Human mechanism: making consequences of purchasing behaviour on people and the Earth experiential leads to more sustainable purchasing decisions Systemic mechanism: allowing direct connection between producers, designers and consumers in buying consumer goods through exchange of resources sets a different economy	Human level: Loop is aimed to address people's the value of personal growth in sustainable living Systems level: Loop introduces an economic system that integrates the value of sustainability

3.5 Systemic design principle 5: Mental models

This principle is based on the idea that systems are created by people and that the mental models of those people have a large influence on the way these systems are shaped. Mental models are the beliefs, values and assumptions that influence people's perception and behaviour (Vink et al, 2019). To change a system therefore often requires that people who have a large influence on these systems change their mental models. In Meadows' (1999) list of leverage points, mental models of system stakeholders are a very strong leverage point.

Design reasoning for mental models includes answering the questions: which stakeholders have power to change the system and should be targeted by the intervention? And what is a means to change or confront mental models that fits the target group and context? Various means have been developed to confront people's mental models and beliefs, including systemic storytelling (Talgorn & Hendriks, 2021), 'sensing surprise' (Vink et al, 2019), embodying alternatives (ibid), perceiving multiples (ibid), and systemic mirroring (van der Bijl-Brouwer & van Loon, 2023). The mechanism in the rationale should include the means for mental model confrontation, the people targeted and using mental models as a leverage point. The outcome or value includes what impact is anticipated on an individual level in terms of mental model confrontation, and the value on a systems level is dependent on the action that these stakeholders take towards systems change. It is important to note that shifting mental models requires time and cannot be controlled. In addition, promoting specific mental models could be considered unethical and needs to be handled with great care.

Example: one of our graduate students recently wanted to design something that would provide actors in the care system around families with special needs children (CSN) with a

new perspective on the effects of that system on CSN parents. She designed a children's book in which CSN parents and system actors are represented by animals and which shows in an empathic way how the collective action of system actors leads to adverse outcomes for CSN parents and therefore also for their children. The children's book was given to read to system actors to help them reflect on their role so they could start redesigning that system with help of that new perspective or 'mental model'. A first evaluation showed that system actors engaged emotionally with the book and some expressed immediately that they started thinking about how they could start changing this care system from within.

Table 5 Design rationale to design for mental models in relation to the care system around parents of a child with special needs

What	How (assumed mechanism)	Value (assumed outcome)
Children's book	Human mechanism: storytelling is a way to emotionally engage people and to change their mental model Systemic mechanism: if system stakeholders in the care system around CSN parents change their mental model of how they see the system, they might change the system from within.	Human level: care system stakeholders perceive their system and the emotional effects it has on parents in a different way Systems level: collectively these stakeholders take action to shift the system in a direction where it provides better care for both child and parent.

4. A skilled practice of systemic design reasoning

In addition to the systemic design principles outlined above, we have developed principles aimed at 'enabling self-organisation' (van der Bijl-Brouwer, 2022) and 'infrastructuring' (Hillgren et al., 2011; Björgvinsson et al., 2012.). The principles were largely developed based on theory and we have experimented with them in our research. In addition, we have applied the principles in education in various parts of our Bachelor and Master programmes in Industrial Design Engineering. In each case, students were presented with a 2-page description of the principles, including references to underlying theories in literature. In addition, we provided students with tutorials in videos and/or lectures to teach them the required accompanying design reasoning practice. Students were asked to choose one of the principles and apply them to a case they were working on, such as food waste, the protein shift, and various health and wellbeing challenges. Students were also coached by an experienced teacher in design. The principles were applied in a second year Bachelor studio course (~6 weeks, 350 students), a second year Master elective course (2 weeks block course, 20 students) and in various graduation projects (20 weeks full-time).

Without presenting a deep analysis of the results developed by students here, it was evident that there was a large difference between the ability to apply systemic design reasoning between the Bachelor students and Master students. Bachelor students very often presented rather naive concepts without a deep analysis of the required mechanisms. For example, many students chose the 'designing for mental models' principle in the case of the

transition to a more sustainable and healthy protein consumption and production system, and then developed a campaign to promote eating less meat. But they failed to reason how a campaign can be made effective for the chosen target group (contextual mechanism), and secondly how a change of mental model of the target group - most of them chose consumers - then would lead to systems change. This contrasts with the work of master student Carine van Loon presented above, in which she conducted in-depth research into the mechanism of storytelling to develop her children's book, and in addition identified which system stakeholders needed to be targeted to read the children's book to change the system from within.

In addition, bachelor students would approach the design process and formulation of the design rationale in a linear way: starting with the desired value, then choosing a systemic design principle as 'how' and then develop a 'what'. With the master students we see more often that students adopt a non-linear way of reasoning that is in line with higher levels of design expertise. As Lawson and Dorst (2009) argue, novice designers use largely rule-based and convention-based thinking. They consider the objective features of a situation and follow strict rules to deal with it. This reasoning process is different from that of design experts, who respond to a situation intuitively, applying design judgement and intention that allows outcomes to emerge. More experienced designers are therefore known to show a practice that is non-linear (van der Bijl-Brouwer, 2019).

This non-linear, emergent expert practice is also required for the systemic design reasoning practice that we promote in this paper. Rather than a linear application of the systemic design principle from desired outcome to principle to design, it requires a going back and forth between the what, how, and outcome on both a contextual and systemic level. Such a practice is in line with Sevaldson's (2022a) argument to develop a 'praxeology' of systemic design'. Rather than a methodology, focused on studying methods that prescribe how to do something, a praxeology studies all aspects of practice, from the application of methods to the "rich and most often overlooked repertoire of competencies, skills, tricks, shortcuts, and rules of thumb that are inherent in all practice" (ibid, p324). Future research is therefore required to further study how systemic design reasoning can be applied in practice, including the application of the systemic design principles presented in this paper.

In addition, we continue to develop our education to train students in systemic design. For example, we have removed the systemic design reasoning from the bachelor program to ensure that students adopt a more advanced level of 'general' design reasoning before integrating the systemic design principles. Instead, we are developing a more elaborate course on systemic design for master students.

5. Concluding remarks

The presented systemic design reasoning practice and accompanying principles complement the more well-known approaches of systemic visualising and designing from within. While the suggested design reasoning practices focuses on 'aspired value' and assumed outcomes,

it needs to be complemented with a 'system conscious design' practice which should be used to anticipate and evaluate unintended consequences and possibly adverse outcomes, for example the Systems Oriented Design evaluation tools proposed by Sevaldson (2022b).

We are continuously (re-) developing the practice and principles in an iterative process of application, evaluation and linking to new theories and insights. We adopt a pluralistic perspective on systems theories and perspectives, exploring pragmatically which theories support the development of interventions and design rationales. The principles are not fixed 'laws' or 'rules', rather they are intended to guide designers in their reasoning process and can be used to explore different options. We have noticed that the principles are not mutually exclusive, but often overlap and can be combined. For example, strengthening social relations contributes to both resilience and to social contagion. While we attempted to present the rationales in a logic table above, we also find that a 'how' is sometimes an outcome of another 'how', leading to a chain of mechanisms and assumptions. The design rationale then becomes what has been referred to as a 'systemic theory of change' (Murphy and Jones, 2021).

The presented systemic design reasoning practice is an overlooked aspect in the systemic design field, as well as in the emerging transition design field. Further research is required to study the role of design reasoning in systems change and transitions; to develop a praxeology that integrates systemic design reasoning with systemic visualisations and designing from within; and to monitor intended effects of interventions on systems and human levels.

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