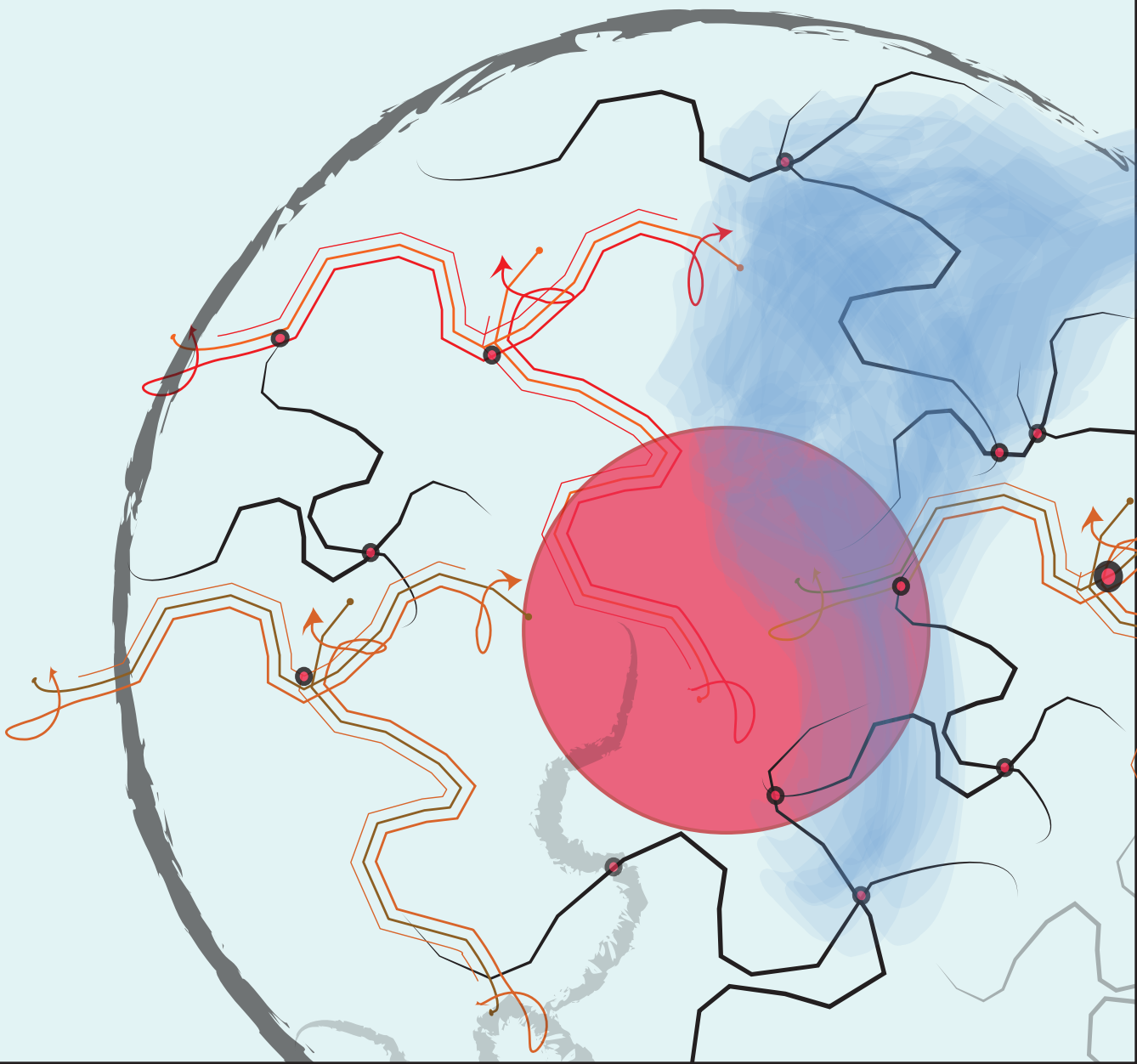


DTRS 14

The role of design in shaping sustainable futures

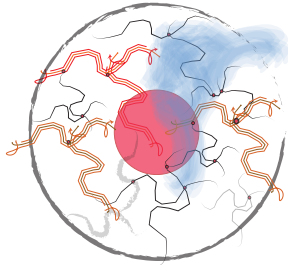
The 14th Design Thinking Research Symposium



DTRS 14

**The role of design in
shaping sustainable futures**

The 14th Design Thinking Research Symposium



Cover image:

An illustration of how a complex design problem can relate to and be interdependent with other things and systems, with intersecting paths and nodes, by Ulrika Florin ¹.

¹ Florin, U. (2022) *On design dialogues: Their roots, features, and usage* p 127. in *Different Perspectives in Design Thinking*, Eriksson, Y. (Ed.).

DTRS 14

**The role of design in
shaping sustainable futures**

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DTRS14 – The role of design in shaping sustainable futures

Focus for the 14th Design Thinking Research Symposium, DTRS14, is sustainability and we have raised the question: What role could design play in the shaping of sustainable futures? The question is motivated since we are facing complex systemic challenges, related to globalization, digitisation, and the need to reduce the negative impact on our environment.

Agenda 2030, and UN:s scaffolding framework with the 17 Sustainable Development Goals (SDG:s), aim to eliminate poverty and hunger, realize human rights for all, achieve equality and empowerment for all women and girls, and ensure lasting protection for the planet, its inhabitants and natural resources. The SDG:s are designed to serve as an integrated resource that balance all three dimensions of sustainable development: the economic, the social and the environmental. This means complexity and we need to take a holistic perspective to make progression. Hence to achieve organizational and societal systems that go in tandem with the Global Goals, we also need to pay attention to various aspects that could contribute to sustainability. The contributions to DTRS14 elucidate various aspect of how design can help us understand what is needed to change the accelerating situation. However, to support and educate future designers to contribute to solutions, addressing the challenges connected to Agenda 2030, it is necessary to involve all levels of education in the challenge and stage crossdisciplinarity teams on different themes.

DTRS14 is hosted by Innovation and design at Mälardalen University, MDU. The vision for MDU is to be a progressive and collaborative university where we together shape a sustainable future. In a strong growth region, we see ourselves as an engine for the entire society and have a responsibility to contribute to people's learning and society's development.

Besides the challenges of climate change, energy supply and resource utilization we are also facing challenges of the present and future that are linked to an aging population, inequalities in health, economic injustices, and threats to democracy. We hope to tackle these challenges through education, research, and innovation. This is done through interdisciplinary approaches, together with our collaboration partners and through our active participation in the public conversation.

This is addressed in research and education in Innovation and design, which is a subject and a research area with an interdisciplinary orientation, focusing on development processes based on the needs of individuals and groups in different situations and contexts. It is about social development to meet current and future needs for change within organisations, companies, authorities, and society at large. Examples of implementations can be communication processes, information processes and innovation, with social relevance and people at the centre. The subject Innovation and design include aspects of information design, innovation technology and innovation management. The subject practices creative approaches as enablers to combine different perspectives and competencies in the creation of artefacts and services as well as in processes and systems based on the individuals concerned. It is common to apply collaborative and user-centred methods that engage different levels of stakeholders in the design and innovation processes.

Internationalization increases the quality of research and education, among other things through the possibility of collaboration with others. The exchange of experience and the knowledge it generates contributes to raising the quality of education. Mälardalen University therefore strives to further develop internationalization, which offers development opportunities, collaboration in research and education and co-production with both the private and public sector and thereby contribute to creating value and benefit both globally and regionally.

The first DTRS was initiated by Nigel Cross with Norbert Roozenburg and Kees Dorst in Delft 1991. Since then, DTRS has been hosted by different universities in countries such as Turkey, USA, Australia, England, Denmark, South-Korea, Israel and now Sweden.

In the context of MDU Living Lab, design methods based on design thinking and soft system thinking have been developed, by participatory design, co-design and by applying ethnographic methods as photo elicitation, to explore together with users and stakeholders. We are therefore happy to publish the proceedings in Mälardalen University Living Lab Press, since the collective contributions present broad perspectives on design research and innovation, with sustainability at core.

Yvonne Eriksson
Ulrika Florin
Karolina Ugglå

Contents

- Page 9 Accommodating varying capabilities in open design: A layered approach for distributed value creation**
Yekta Bakırhoğlu, Lancaster Institute for the Contemporary Arts, Lancaster University
- Page 25 Zero-waste Food Deliveries and Takeaways: Sustainable Design Solutions through Systems Thinking**
Yekta Bakırhoğlu, Lancaster Institute for the Contemporary Arts, Lancaster University
Çağla Doğan, Department of Industrial Design, Middle East Technical University
Owain Pedgley, Department of Industrial Design, Middle East Technical University
Bahar Şener, Department of Industrial Design, Middle East Technical University
- Page 41 Do Make me Think - Towards an Integrated Model for Sustainable UX Design.**
Jesper Balslev, Ph.D., Copenhagen School of Design and Technology
Steen Carlsen, senior lecturer, Copenhagen School of Design and Technology
Peter Tolstrup, associate lecturer, Copenhagen School of Design and Technology
- Page 57 Design of a Co-evolutionary Approach for Sustainable Educational Ecosystems**
Anders Berglund, Mälardalen University
- Page 69 Food Sharing as a Community Design Approach**
Abdullah Tarik Celik, Istanbul Technical University
Witold Budzyński, Cracow University of Technology
Cigdem Kaya, Istanbul Technical University
- Page 91 Design thinking for sustainable futures: opportunities to connect with other approaches**
Nathan Crilly, University of Cambridge
- Page 107 Designing for hypercomplexity: a case study**
Kees Dorst, University of Technology Sydney
André Schaminée, TwynstraGudde

Page 121 Future Hunter: framing social change in times of transition

Kees Dorst, University of Technology Sydney
 Rodger Watson, University of Technology Sydney
 Simon Byrnes, University of Technology Sydney

Page 135 Layer-by-layer Design.

Design Inference in Additive Manufacturing for circularity.
 Noemi Emidi, Politecnico di Torino

Page 151 Design and R&D Process of an Autonomous Water Surface Cleaning Vehicle

Oğul GÖRGÜLÜ, İzmir University of Economics, İzmir
 Can ÖZCAN, İzmir University of Economics, İzmir

Page 167 Bridging the Paradox: Exploring Trajectories for Sustainability in Digital Design Education and Practice

Per Liljenberg Halstrøm, Copenhagen School of Design and Technology (KEA)
 Sarah O'Neill, Copenhagen School of Design and Technology (KEA)
 Jonas Fannikke Holbech, Copenhagen School of Design and Technology (KEA)
 Alan Engelhardt, Copenhagen School of Design and Technology (KEA)

Page 183 Reshaping University — Industry Collaboration with Design Thinking

Verena Kaiser, Hochschule München University of Applied Sciences
 Bettina Maisch, Strasczeg Center for Entrepreneurship (SCE) and Hochschule München University of Applied Sciences

Page 199 Investigating Gender Bias in Engineering Design Theory and Methodology

Samantha Kang, Oregon State University
 Christopher Sanchez, Oregon State University
 Andy Dong, Oregon State University

Page 215 Bamboo Houses in Bali: Evaluating Locals' Perception to Promote Sustainable Construction Materials

Audrey Mertens, University of Liège
 Catherine Elsen, University of Liège

**Page 231 Generative Design Research Methods for Sustainability:
Graduate Research and Design Interventions on Effective
Use of Water**

Dilruba Oğur, Middle East Technical University, Department of Industrial Design

Çağla Doğan, Middle East Technical University, Department of Industrial Design

Senem Turhan, Mälardalen University, School of Innovation, Design and
Engineering

**Page 247 Supporting Reflexivity and Action on Equity and Justice in
Design Education: Insights from the Design Justice
Pedagogy Summit**

Anastasia K. Ostrowski, Massachusetts Institute of Technology

Madhurima Das, Massachusetts Institute of Technology

Gillian Roeder, Massachusetts Institute of Technology

Jana I. Saadi, Massachusetts Institute of Technology

Christina Harrington, Google Research

Aditi Verma, University of Michigan

Cynthia Breazeal, Massachusetts Institute of Technology

Catherine D'Ignazio, Massachusetts Institute of Technology

Maria Yang, Massachusetts Institute of Technology

**Page 263 Living-Centered Design: Embracing Collaboration and Co-
Creation with Nature for a Sustainable Future**

Carla Paoliello, FBA ULisboa / CIEBA

Ana Vasconcelos, FBA ULisboa / CIEBA

Rui Faria, FBA ULisboa

**Page 277 From Empathetic to Reflective Dialogue:
A Visual Tool for Future Social Design Education**

Michal Pauzner, Shenkar - Engineering. Design. Art.

Jennifer Schubert, TH Augsburg

Jonathan Ventura, Shenkar - Engineering. Design. Art.

**Page 299 Redefining household activities: a metaphorical approach
to energy for shaping sustainable futures**

Resat Sasik, Luleå University of Technology

**Page 315 An Inception Fairytale – Stories on the Sustainable Future
in a Technology Center**

Andreea Strineholm, Mälardalen University

Jennie Schaeffer, Mälardalen University

- Page 331** **Reimagining Sustainable Innovation: ReEVOLUTION 6, a Design Thinking Model for Circular Economy**
Katja Tschimmel, ID+ Research Institute for Design, Media and Culture, Porto University and Mindshake
Joana Alves dos Santos, Mindshake - Consultancy for Creative Thinking and Design
- Page 353** **Across the Parallax: Human-Centered Design as a Community Engagement Tool**
Peter Tschirhart, Texas State University
Claudia Röschmann, Texas State University
- Page 367** **Who Framed the Government Architect?: Cultural residue, and a role for design in reshaping organizations**
Rodger Watson, University of Technology Sydney
- Page 383** **From Past Pandemics to Future Health Crises: A Systemic Design Framework for Building a Healthier Future**
Wibke Weber, ZHAW University of Applied Sciences
Valery Wyss, ZHAW University of Applied Sciences
Felicitas Högger Niedermann, ZHAW University of Applied Sciences
Louis George Schäfer, ZHAW University of Applied Sciences
Joël Floris, UZH University of Zurich
Kaspar Staub, UZH University of Zurich
- Page 397** **Exploring Innovation Management System to Understand and Secure Preconditions for Design Thinking**
Anders Wikström, Mälardalen University
Carl Heath, RISE; Research Institute of Sweden
- Page 413** **Understanding the Needs of Nonhuman Stakeholders in Design Process: An Overview of and Reflection on Methods**
Berre Su Yanlıç, Arçelik Research Center for Creative Industries, Koç University
Aykut Coşkun, Arçelik Research Center for Creative Industries, Koç University

Accommodating varying capabilities in open design: A layered approach for distributed value creation

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ABSTRACT

Open design challenges the traditional notions of design, innovation, and business by enabling and facilitating collaborative and distributed value creation. However, simply making designs open cannot enable their adoption by others and facilitate distributed production or local circular economies. In pursuit of a novel understanding of how open design can be adopted and utilised to manage distributed value creation, this paper presents the results of eight co-creation workshops conducted with Networked Business Model Canvas for exploring alternative business models and practices in distributed value creation networks. A total of 127 value creation nodes in 11 alternative open design-led distributed value creation networks were conceptualised during the workshops. Their analysis revealed various implications and challenges of open design for managing distributed value creation, which led to the development of a novel layered approach to designing open products that can accommodate varying capabilities and levels of engagement of different stakeholders, from end-users to producers.

Introduction

Open design and distributed production are emerging paradigms that involve stakeholders collaborating to create, share and modify design artefacts and challenge the traditional notions of design, innovation, and doing business. This is different from other co-design methods that seek a final design outcome as a consensus of a group of stakeholders. Open designs can be peer-reviewed and improved by peer-to-peer feedback and can branch or fork towards various new designs that suit the needs, wants and preferences of different groups of people working on them. With the advancement of desktop fabrication tools, such as 3D printers and laser cutters, and their increased accessibility through fab labs and maker spaces, open design creates opportunities for more open collaborative innovation processes (Thackara, 2011), distributed fabrication (Ramos, 2017), self-repair (Bonvoisin, 2017) and the circular economy (Prendeville et al., 2016). These opportunities suggest increased localisation, democratisation and socially and economically empowering processes of production and consumption. However, there are also limitations, such as the physicality and complexity of open design and hardware (Malinen et al., 2011; van der Bij et al., 2013), quality control and safety (Cruickshank & Atkinson, 2014), and required skills and capabilities to partake in open design and distributed value creation processes (Phillips et al., 2013). These

limitations suggest a need for re-thinking open design by challenging the assumptions that making designs open will enable their adoption by others and facilitate distributed production or local circular economies. Rather, it becomes crucial to recognise and respond to the highly varying capabilities of different stakeholders that can potentially partake in distributed value creation processes and envision and accommodate all these different forms of participation. Accordingly, this paper argues for a novel understanding of how open design can be adopted and utilised to manage distributed value creation, as explored in 8 co-creation workshops using the Networked Business Model Canvas.

Background

Open design solutions and open-to-participate processes

Open design refers to both design outcomes that anyone can adopt, alter and fabricate and design processes in which everyone can participate (Bakırlioğlu & Kohtala, 2019). The openness of design outcomes enables horizontal management of the processes, as well as collaboration by iteration resulting in branching toward novel design directions and outcomes (Tooze et al., 2014). The openness of the process enables peer-to-peer feedback to improve the outcomes via various perspectives beyond disciplinarity. These conceptualised aspects of open design are discussed alongside more open collaborative innovation processes, distributed fabrication, self-repair, and the circular economy (Bonvoisin, 2017; Huizingh, 2011; Prendeville et al., 2016; Ramos, 2017; Thackara, 2011). However, especially physical open design outcomes pose several challenges to the broadening and inclusive innovative potential of open design (van der Bij et al., 2013). The peer review process, which is very effective in finding and correcting bugs and enhancing codes thanks to online sharing and duplication through the copy-paste function in open-source software, does not apply well to more complex, physical open designs (e.g., cars, electricals) where parts and components need to be reconstructed from scratch by everyone who wants to participate (Malinen et al., 2011; Müller-Seitz & Reger, 2010). Also, since the fabrication is distributed and, in theory, everyone can fabricate open designs, the issue of reliability and user safety of open designs emerges due to the lack of oversight in fabrication processes (Cruickshank & Atkinson, 2014). Finally, although everyone is expected to be able to adopt, alter and fabricate these designs, only makers, prosumers and alike, who have the skills and resources, can actually participate in this open design process in real life, especially in their fabrication (Phillips et al., 2013; Reinauer & Hansen, 2021; Woodson et al., 2019). Accordingly, the potential of open design and knowledge sharing is diminished without a lasting horizontal community and alternative business models supporting and mainstreaming it to reinvent and transform existing consumer products (Troxler & Wolf, 2017).

Forms of value creation and stakeholders

The traditional separation among users, designers and producers has long been challenged by various approaches such as participatory design (Björgvinsson et al.,

2010) and codesign (Fuad-Luke, 2013), and the lines among stakeholders are getting increasingly blurry in the past couple of decades, espousing hybrid roles and novel forms of collaboration (Stappers et al., 2011). Open design and distributed production, the way it is conceptualised in this paper, suggests participation in more diffused networks of value creation, localisation of such processes for better, more meaningful design outcomes and value re-capture through local circular economies. However, participation in the stages of design, production/fabrication and post-use processes of products requires highly diversified sets of knowledge, skills and resources that are hard for an individual to possess all. Furthermore, these capabilities also vary greatly among different types of products (Müller-Seitz & Reger, 2010). Considering these, it should also be recognised that individuals do not have the capability to partake in the value-creation processes of all the artefacts they have, nor would have the capacity to do so.

The literature on open design, maker movement and distributed production has utilised various forms of categorisation to represent varying capabilities and engagement of individuals and other stakeholders. These include the taxonomy of active user engagement (Kohtala et al., 2020) identifying four forms of user participation (i.e., use-as-is, active use, user design and user innovation), the forms of DIY practices (Fox, 2014) that distinguish DIY innovation, prosumption, and DIY entrepreneurship that facilitates prosumption, the division between makers as social entrepreneurs/enterprises or makers as dependent social idealists focusing solely on sharing of knowledge and resources (Langley et al., 2017), and local entrepreneurs and individual makers in the context of industry 4.0 (Fiaidhi & Mohammed, 2018). Through a systematic literature review, the author has previously identified a novel conceptualisation of stakeholders in distributed value creation networks according to the ways they can participate in such networks (Bakırlioğlu & Hasdoğan, 2022). Accordingly, there are two main categories of stakeholders: the ones that create value for themselves and their communities, namely responsible consumers (RC), active users (AU), and prosumers/makers (PM), and the ones that create value for others, i.e., local, regional, and global/mass producers (LP, RP, and GMP) (Bakırlioğlu & Hasdoğan, 2022). These stakeholders build on top of each other's value creation processes (i.e., design, production/fabrication, and post-use) at the global, regional, local, and individual scales, which can potentially result in resilient networks of distributed production and increasingly localised circular economies.

This paper presents a layered approach to designing through the exploration of alternative value creation nodes as part of the DF-MOD (Distributed Fabrication through Mass-produced Open Designs) project. The explored nodes are facilitated through mass-produced open design parts and products present a potential for the recapture of the added value of parts and components within local circular economies, and account for the diverse skills, knowledge and resources of different value-creation-for-self (VCFS) and value-creation-for-others (VCFO) stakeholders, as well as their active involvement into design, production and post-use within distributed value creation network.

Methodology

Exploring the potential of distributed production that is enabled, facilitated, and sustained by open design involves the exploration of alternative ways of doing business in such networks. However, while the ways the business models are developed vary greatly and bring forward either rational reasoning in business operation (i.e. rational positioning), experimentation and continuous improvements (i.e. evolutionary learning), or uniqueness of perspectives (i.e. cognitive), existing business models tend to be altered in the face of external variables affecting their economic viability rather than conceptualising new ways of doing business (Gudiksen et al., 2014; Martins et al., 2015; Mootee, 2013). The past decade, however, witnessed the emergence and increased use of alternative ideation tools for conceptualising business models, such as the notable Business Model Canvas (Osterwalder & Pigneur, 2010) and its more focused iterations (e.g., Maurya, 2012; Osterwalder, 2016; Osterwalder et al., 2014; Upward & Jones, 2015). In the design field, participatory approaches are being explored in the development of new business model ideas resulting in novel generative tools and techniques (Gudiksen et al., 2014). These frameworks are compatible with the concept of a business model that is centred around a main business/firm, identifies its components, the relations between them and the organisational activities carried out through them (Afuah & Tucci, 2001; Zott & Amit, 2010). However, such a business model concept is not compatible with the networked value creation distributed at global, regional, local, and individual settings, which facilitates numerous businesses and individuals to build value on top of each other.

DF-MOD project aimed to explore the potential for open design-led business models that facilitate distributed value creation with a focus on electrical household appliances. As part of this project, the author introduced a novel conceptualisation of distributed value-creation stakeholders under two main categories, i.e., value-creation-for-self (responsible consumers, active users, prosumers/makers) that create value for themselves and their communities, and value-creation-for-others (local, regional and global/mass producers) that formally operate as businesses through a systematic literature review (Bakırhoğlu & Hasdoğan, 2022). He, then, conducted an extensive survey to understand the skills, resources, and capabilities of these stakeholders for design, production, and post-use practices in distributed value creation of electrical household appliances in Turkey (Bakırhoğlu, 2023). Finally, he facilitated eight co-creation workshops facilitated by the Networked Business Model Canvas, which explored potential open design-led distributed value creation networks and nodes in detail, and revealed open design considerations that can enable and manage such distributed value creation networks.

Networked Business Model Canvas

Exploring business models and practices that facilitate, activate, and sustain resilient distributed value-creation networks requires an exploration of the networks themselves and the value-generating relations among value-creation-for-self and value-creation-for-

others stakeholders. For this purpose, the author developed a generative design research tool titled Networked Business Model Canvas (Fig. 1) that aims to imagine and explore alternative ways of doing business in distributed value creation networks managed by open design knowledge (Bakırlioğlu, 2022). Generative design research methods aim to uncover more profound knowledge by facilitating people's organisation of thoughts and ideas (Hanington, 2007; Sanders et al., 2010), and such methods have been used for the development of new business model ideas espousing novel ways of doing business (Gudiksen et al., 2014). Constructive tools are especially useful for generating and expressing novel ideas, and they can be adapted for individual or group work and can also be implemented online or face-to-face (Sanders et al., 2010).

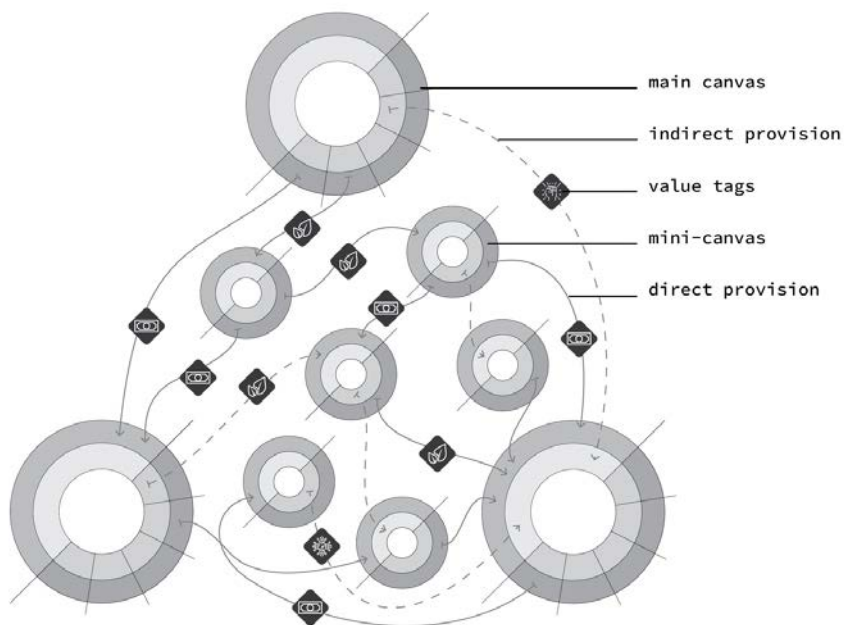


Fig. 1: Parts of the networked business model canvas, namely main canvases, mini-canvases, provision lines and value tags (economic, environmental, social, and cultural). For more details about the tool, refer to Bakırlioğlu, 2022.

The Networked Business Model Canvas (N-BMC) focuses on distributed value creation networks with numerous stakeholders participating in value creation processes at varying capacities, rather than exploring singular, focal businesses/firms, in order to grasp the complexity of relationships among these stakeholders that take crucial roles in value creation and capture since these processes are conceptualised as *distributed* both geographically and among multiple, and possibly interchangeable, stakeholders. N-BMC consists of four main components: (1) Main canvases for stakeholders the participants

intend to explore in detail, (2) Mini-canvases for other stakeholders in distributed value creation networks, (3) Provision lines to draw the link between one stakeholder's output and another one's input, and (4) Value tags to identify the kind of values generated through these relations. There are four types of value tags, (a) economic, (b) environmental, (c) social, and (d) cultural.

Co-creation workshops

As part of DF-MOD, eight N-BMC workshops were conducted with 38 participants in total. Purposive and snowball sampling was utilised to attract experts with different disciplinary backgrounds, and the participants included designers, engineers, researchers, craftspeople, managers, and other experts. The calls for participation were done through specific communications channels, such as through a workshop session at a national design conference, emails to participants of previous stages of the project, and bulk emails or messages to established DIY and maker communities in Turkey. The inclusion criteria were very straightforward and mostly inclusive, as the calls specified AUs, PMDs and representatives of LPs, RPs and GMPs as targeted participants, yet it was also specified that the sessions would be open to all. The spread of different backgrounds and expertise in workshop sessions was satisfactory for the exploration of distributed value-creation networks throughout the sessions and sparked fruitful group discussions. These workshops resulted in the conceptualisation of 11 different alternative open design-led distributed value creation networks consisting of 127 value creation nodes (for-self and for-others) in these networks, as illustrated in Table 1.

Table 1. Starting points, number of potential distributed value-creation network stakeholders explored in each workshop, and identifiers of value-creation nodes introduced in this paper

	Starting points	Explored stakeholder types							Other	Total
		VCFO			VCFS					
		GMP	RP	LP	PM	AU	RC			
WS1	Air fryer, robot vacuum cleaner	6	5	6	1	2	2		22	
WS2	Turkish tea maker/ kettle	1	2	2	1	3	2	1	12	
WS3	Energy saving/ gen.	3	3	4	2	1	1	2	16	
WS4	Food prep.	2	3	2	1	2	2		12	
WS5	Electric pot, air fryer	3	3	2	2	1	1	1	13	
WS6	Robot vacuum cleaner, Turkish tea maker/ kettle	6	5	6	1	2	2	2	24	
WS7	House cleaning appliances	2	2	3	2	2	1	1	13	
WS8	Food preparation appliances	3	3	4	2	1	1	1	15	
Total	11 networks	26	26	29	12	14	12	8	127	

The nodes explored during the workshops were conceptualised according to (1) their inputs, processes, and outputs (categorised according to (a) resources, objects, and services, (b) licensing, and (c) knowledge), (2) the links between these stakeholders depicting the flow of knowledge and resources in these networks, and (3) the identification of different forms of value generated with these links. Fig. 2 illustrates an

example of such a node: a local parts and components manufacturer for unique needs and preferences that produces one-off kitchen appliances and offers services around it. These revealed various points of analysis regarding the forms of operation and value creation (inputs, processes, and outputs), practices of value (re-)capture (through links), distributed forms of value creation (through multiple stakeholders linked), and types of value generated. Since the analysis was focused on the potential of networked value creation, a secondary analysis of inputs and outputs (i.e., resources, objects, services, licensing, and knowledge) revealed considerations about how open design can facilitate, sustain, and flourish these distributed value creation networks.

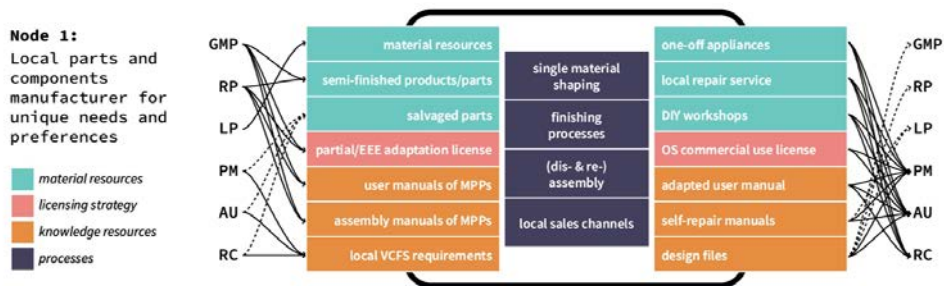


Fig. 2: An example of alternative business models conceptualized during the N-MBC workshops.

Designing for distributed value creation

The Networked Business Model Canvas enabled not only the exploration of alternative open design-led business models in distributed value creation networks but also the exploration of how open designs need to be so that they can operate in such networks. Considering that these business models require a different approach to designing, and horizontal management of distributed value creation networks based on the openness of design outcomes, this paper presents a layered approach to design that can facilitate iterative collaboration.

Layered design outcomes & collaboration by iteration

Various dimensions of business model development can be explored using the networked business model canvas and distributed value creation network conceptualisation of the DF-MOD project. As part of the workshop sessions, participants explored distributed value creation networks that are enabled by open design and production knowledge and explored the various levels of participation in distributed value creation networks from the perspectives of value-creation-for-self and value-creation-for-others stakeholders. It went beyond the concept of a single stakeholder and its business operations. Instead, distributed value creation networks were explored through open-ended design and production processes, with stakeholders creating value

on top of each other's value creation processes through *collaboration-by-iteration* (Bakırlioğlu & Hasdoğan, 2022) that is neither managed by a primary stakeholder nor oriented towards a predetermined outcome. The prominent, alternative business models and their value creation processes all presented such iterative value creation that either initiates such an iterative process or continuously deploys iterative design and production/fabrication processes as the value offering.

Beyond the business model design in terms of its internal processes, IPR strategies and relations to other stakeholders in distributed value creation networks, such a *collaboration-by-iteration* process also requires a different approach to how things are designed. Outputs of such business models need to accommodate *the capacity to be iterated* in the first place, and by both value-creation-for-self and value-creation-for-others stakeholders that have widely diversified resources, skills, and capabilities. Accordingly, designing a product involves more than the modularity of parts and features; rather, it involves identifying and accommodating stakeholders' varying levels of engagement. A layered approach to open design evolves in this context, in which practitioners layer value offerings according to their levels of engagement.

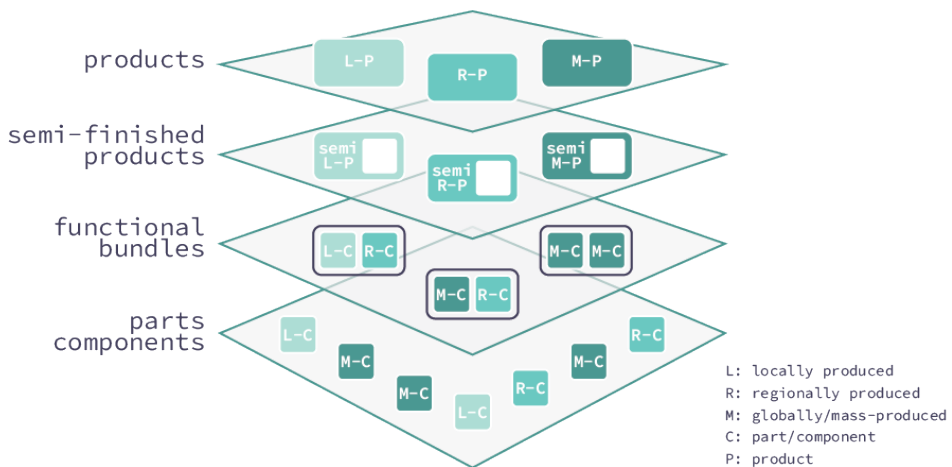


Fig. 3: Open design layers to accommodate varying resources, skills and capabilities of DVCN stakeholders

Accordingly, four broadly defined levels were observed during the workshops that accommodate different levels of engagement (Fig. 3), as follows:

- *End-user products layer* is rather straightforward and refers to fully functional products designed and produced by local, regional or global producers. These outputs are addressed to responsible consumers and active users, and active users can personalise them with add-ons and other external interventions. While

these do not offer much room for design intervention, alternative ecosystems that work with these products can also be designed.

- *Semi-finished products layer* involves products with missing parts or components to be designed, produced/fabricated and assembled by regional and local producers, prosumers/makers or active users. There are nodes that cannot design and produce complete products, but that may not be necessary in distributed value creation networks that enable collaboration-by-iteration. In this case, the 'semi-finished product' in question is a layer of that open design system between functional bundles and products.
- *Functional bundles layer* involves sets of parts, components and software designed to deliver certain functions. They are designed to deliver these functions while bypassing the assembly and testing of individual parts and components. These bundles enable regional and local producers and prosumers/makers who lack certain capabilities to produce/fabricate and assemble certain types of parts and/or assure their quality and safety.
- *Parts/components layer* is also rather straightforward and involves the parts and components produced by local, regional and global/mass producers. These stakeholders can provide these parts on their own and as parts of functional bundles, semi-finished products or end-user products.

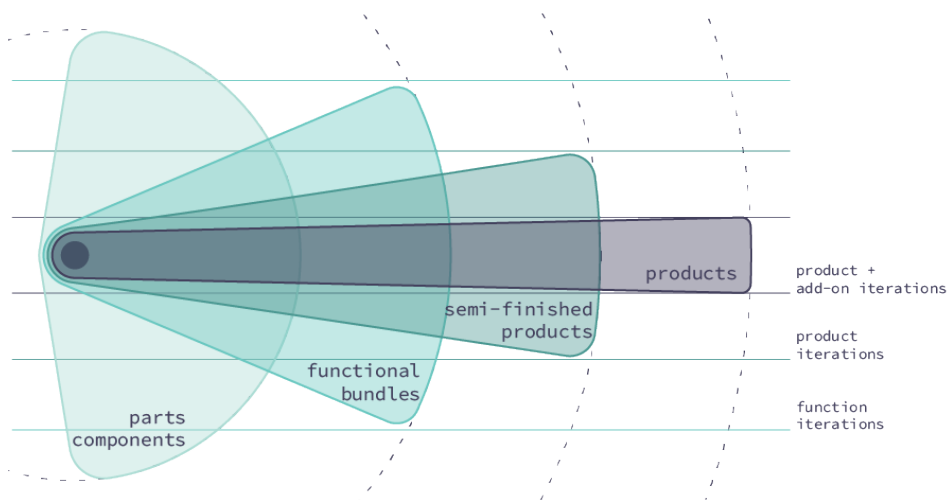


Fig. 4: Reach according to required skills, resources and capabilities & potential for iteration imposed by layers of open design 'things'

In Fig. 4, the potential reach of distributed value creation networks is depicted according to the layers of design present in them. Horizontal lines represent the potential for open design iterations, i.e., inner lines represent products coupled with add-on iterations,

mid-lines represent iterations of a product, and outer lines represent different kinds of products/objects using similar functions. The circular dotted lines represent stakeholders' knowledge, skills and resources, i.e., the innermost dotted circle has the most wide-ranging knowledge, skills and resources, and the outermost dotted circle has the least-ranging knowledge, skills and resources. For example, open design parts and components can be used in the production/fabrication of wide-ranging designs and iterations with different functional and aesthetic features; however, utilising them would require wide-ranging knowledge, resources and skills and thus can be utilised by a smaller number of stakeholders. On the other hand, open semi-finished product designs will not allow such wide-spreading possibilities on their own; they can be used by value-creation-for-others and value-creation-for-self stakeholders with limited resources, skills and capabilities and thus can be utilised by more stakeholders in distributed value creation networks. It is important to consider all layers and provide alternatives for unconstrained iterative design processes as well as more constrained but easily adoptable value creation processes. This may seem like a conflict between the potential for innovation and the potential for inclusivity, but open designs can accommodate both sides by adopting a layered approach and designing for all layers.

Formalising distributed production through open design management

There are numerous stakeholders in the proposed collaborative process, who operate in parallel and iterate value offerings in different directions. The networked business model canvas was developed with this conceptualisation in mind, where numerous value-creation nodes (i.e., value-creation-for-self and value-creation-for-others stakeholders) freely operate within distributed value creation networks and form value-creating links among each other. Thus, singular business models may not be sufficient to manage distributed value creation networks. With appropriate licensing strategies, open design knowledge (both processes and outcomes) can serve as an effective management tool that is transparent, accessible, and responsive to stakeholders' needs and preferences. In this case, the issue is the complicated open-source license landscape caused by existing IPR laws that separate novel functional inventions (e.g., patent laws), original creative work (e.g., copyright laws, design registrations), and source (e.g., trademark laws). Various open-source licensing types and certification schemes were espoused in response to this fragmented landscape, such as CERN Open Hardware License (CERN-OHL) for hardware innovation, Creative Commons (CC) for digital creative work, Open-source Hardware Association (OSHW) certification for showing appropriate OS licensing of designs, hardware and sources, among many others.

The fragmented nature of the IPR management landscape makes it difficult to navigate for many stakeholders, leading many local producers to avoid it altogether (Bakırlioğlu, 2023). Additionally, opening designs in terms of not only design knowledge and data but also open licensing of design outcomes that protect their openness, as well as intellectual property rights of their sources, remains an immense barrier against widespread adoption of open design practices, let alone the distributed value creation

networks that localise on-demand production as conceptualised here. It is already a challenge for many open design practitioners and communities to document and share their work, especially open designs of physical objects (Bakırhoğlu & Kohtala, 2019). It requires additional effort from stakeholders of distributed value creation networks to navigate the existing intellectual property landscape while at the same time protecting the openness of designs and commercialization rights. OSHWA is a good example of how the openness of various aspects of designs can be managed, and how it can assure other stakeholders that they aren't infringing upon the IPR of the initial open design. Even so, it is still an additional step after properly licensing open designs and does not reduce the amount of work involved. In order to geographically expand and localise production through initial open designs and their iterations, stakeholders who create value for others and stakeholders who create value for themselves would also need to go through complex licensing and certification processes.

Depending on the complexity of the product, the safety requirements, and other external factors (i.e., standardisation, policy, etc.), a layered approach to open design can alleviate this fragmented IPR landscape or exacerbate it. Most of the value creation nodes in the co-creation workshops relied on a loosely defined 'partial adaptation licensing', which would allow value-creation-for-others stakeholders to engage in limited commercial activities with open designs. However, descriptions of these limits varied greatly in different workshops. Discussions around this during the workshops focused on safety and benefits, and how value-creation-for-others stakeholders can ensure that their open design iterations still meet the safety requirements of electrical appliances. According to these discussions, making designs 'open' by itself may not suffice, and managing distributed value creation networks must involve clearly defined limits, quality control, and assigning responsibilities for parts, functional bundles, and semi-finished products. How these processes can be horizontally managed and enable value-creation-for-others and value-creation-for-self stakeholders to democratically and freely participate in distributed value creation networks requires further exploration through research and practice.

Conclusion

Through an exploration of open design and distributed production for electrical household appliances, this paper proposes a layered approach to designing open products that can accommodate different levels of engagement and capabilities of various stakeholders, from end-users to producers. Using a generative tool, Networked Business Model Canvas, for conceptualising alternative business models and practices in distributed value creation networks based on open design knowledge and processes, eight co-creation workshops were conducted as part of the DF-MOD project, which led to the development of 11 different open design-led distributed value creation networks. These networks consisted of 127 nodes in total, and their analysis revealed various implications and challenges of open design for managing distributed value creation. This led to the development of a layered approach to designing, which involves four layers:

end-user products, semi-finished products, functional bundles, and parts/components. Each layer represents a different degree of openness, customisation, and complexity, and allows different actors to participate in the design and production process according to their preferences and varying capabilities.

The paper contributes to the literature on open design and distributed production by providing a novel framework for designing for open design-led business models, as well as a nuanced exploration of the feasibility and diversity of open design-led distributed value creation networks. The paper reveals future directions for research and practice, such as exploring the impact of open design on environmental sustainability (e.g., through comparative analysis of environmental impact and value re-capture), social inclusion (e.g., through varying levels of involvement in distributed value creation processes at different localities), and innovation diffusion (e.g., through branching and forking of open designs into novel directions), as well as developing methods and tools for evaluating and improving the performance and quality of open products and distributed value creation networks especially in different product sectors. The paper hopes to inspire and inform designers, innovators, entrepreneurs, and policymakers who are interested in harnessing the potential of open design and distributed production for creating value in more collaborative, democratic, and sustainable ways.

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Zero-waste Food Deliveries and Takeaways: Sustainable Design Solutions through Systems Thinking

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ABSTRACT

The food delivery and takeaway sector generates significant food and packaging waste, posing environmental challenges. In response, this paper presents the process and outcomes of an educational design project that guided students to develop sustainable design solutions for zero-waste food deliveries and takeaways. The project involved 85 students who worked in teams to design a service system and a product family using a systems thinking approach to address the complex network of stakeholders, value propositions, and material flows involved in these services. The paper describes the project stages, the tools and methods adopted for systems thinking, and the pedagogical outcomes regarding design processes and proposals. The paper discusses the implications of the project for reimagining the food delivery and takeaway sector in ways that promote sustainable food practices, support local resources and know-how, and achieve zero food and packaging waste. The paper also reflects on the role of systems thinking in elevating design students' capabilities to deal with complexities inherent in multi-stakeholder problem spaces.

Keywords: systems thinking, sustainable design solutions, business model canvas, food experience, zero waste, educational design project

Introduction

Single-use disposable food and beverage products have become a great environmental problem due to influencing factors such as convenience and hygiene. This was heightened as part of the COVID-19 measures (Molloy et al., 2022), but it persisted even after the restrictions were lifted. When businesses such as canteens, cafeterias, and small restaurants use excessive packaging for takeout and delivery, it contributes to the growing problem of plastic waste (Kochanska et al., 2021), including items such as plastic containers, cutlery, stretch films, and bags. Over-consumption is compounded by the additional problem of excessive food waste due to poor portioning practices and over-ordering tendencies that arise from increased use of delivery and takeaway services (Trivedi et al., 2023). Through a systems thinking approach, design solutions

can be generated that invite a rethink in business and consumer practices, push for more sustainable alternatives, and help designers make better-informed decisions about the entire cycle of the takeaway food experience, including preparation, storing, packaging/transporting, and serving. This constitutes a rewarding challenge for future designers who can foster skills and capabilities in design for sustainability to explore and address intervention areas within complex systems. Hence, we incorporated system thinking into a 14-week-long design project carried out with 85 students at the Department of Industrial Design, Middle East Technical University, Turkey. The project involved conceiving and developing sustainable design solutions in the form of a product family targeted at re-imagining the entire cycle of the takeaway/delivery food experience for healthy and responsible eating and consumption.

Background

Systems of food delivery and takeaway: opportunities and challenges

The food delivery and takeaway services sector has been built around the use of various single-use packaging to ensure that foods reach their destination without getting messed up, without becoming cool (in the case of warm food), and in a form that can be easily handled from kitchen to table. These demands have led to the use of very common single-use material-container combinations, such as cardboard boxes, expanded polystyrene plates, aluminium foil trays, polystyrene cutlery and drink cups. The sector experienced substantial growth during the COVID-19 pandemic, with changing consumer behaviours and expectations and numerous cafes and restaurants switching to this business model simply for survival and new delivery-focused businesses entering the sector (Jia et al., 2022). This was accompanied by advancements in online ordering technology and third-party platforms offering secure transactions, customer support, and courier delivery services. These developments have transformed the sector in line with increased interest in convenience, variety, and personalisation in food choices and increased awareness of health, ethical, and environmental aspects of food consumption. However, this also led to even more complex networks of stakeholders in food production, distribution and consumption and negatively impacted the food and other associated waste production (e.g. packaging, CO2 emissions from delivery services, etc.) (Marcantonio et al., 2021). For example, food delivery apps may promote questionable behaviours in line with their business models, such as excessive food consumption or excessive food purchases leading to food waste (Gunden et al., 2021), poor working conditions for couriers (Muszynski et al., 2022) and severe environmental impact due to excessive packaging (Jia et al., 2022).

The complexity of the food production and consumption networks has been problematised from diverse disciplinary perspectives (Gallego-Schmid et al. 2019; Scherhauser et al., 2018). In general, the most impactful interventions against food waste are considered to be towards prevention, by avoiding food surplus across the supply chain, reducing over-purchasing on the consumer side, and avoiding premature disposal

of food (Papargyropoulou et al., 2014). Such impactful interventions require strategies and actions to be developed together with a multitude of stakeholders (Aschemann-Witzel et al., 2015). Focusing more specifically on the delivery and takeaway services, most of the studies focus on promoting recycling and waste separation behaviour or food waste reduction (e.g., Ding, 2022). Reusable food containers for such services are mostly disregarded, with only a handful of such studies attempting to explore consumers' perceptions and behaviour towards reusable containers in delivery and takeaway services (e.g., Sia et al., 2023). This is also reflected in the market, where the major efforts are towards improving packaging designs in terms of portioning, shelf life, and storability (e.g., Aschemann-Witzel et al., 2015) and technological interventions (e.g., smart packages, material innovations) (e.g., Parfitt et al., 2010).

Tackling food and packaging waste through systems thinking and design

The design literature has increasingly addressed the complex issue of food waste over the past few years. There are studies on the design of the food itself (e.g., Lee et al. 2020), the aesthetic qualities of food experience (e.g., Schifferstein et al. 2023), informing healthy food choices (e.g., Bomfim et al. 2023), behaviours and practices that cause food waste (e.g., Ganglbauer et al. 2013), and improving the storage and shelf life of food (e.g., Birhanu & Belay, 2023), among others. Recently, more collaborative processes in rethinking and reimagining food systems have begun to be explored, such as the special issue titled 'Co-Creating Sustainable Food Systems' published in the *International Journal of Food Design* (Wertheim-Heck & Herrera, 2023). However, there remains a gap in design literature regarding the increased use, and thus increased impact, of the food delivery and takeaway sector, which needs to be tackled from various angles. This includes not only resultant food waste, resultant excessive packaging waste and behaviour change towards waste prevention at the consumer level but also the roles of numerous stakeholders in food systems.

Different approaches to systems thinking are advocated in the design literature to understand and/or initiate societal transformations, especially in design for sustainability research. The acknowledgement of the need for systems-level change towards sustainability was reflected in this body of literature (Bhamra & Hernandez, 2021) with the emergence of systemic design (e.g. Jones & van Ael, 2022; Van der Bijl-Brouwer & Malcolm, 2020), design for sustainability transitions (e.g. Joore & Brezet, 2015; Ceschin & Gaziulusoy, 2016; Mok & Hyysalo, 2018), sustainable product-service systems (e.g. Vezzoli et al., 2015), and many others. The systems-thinking approach has been adopted in recent studies with an emphasis on promoting reusable alternatives considering design for sustainability. For instance, Long et al. (2021) explore how to apply product-service systems to reusable packaging systems in order to address the plastic waste problem in the food and household products industry. The authors propose a strategic design tool that can classify, analyse, and generate different types of reusable packaging systems based on a combination of case studies and expert interviews. More notably, they identify 15 reusable packaging PSS archetypes, focusing

on different yet focused aspects of food purchase and delivery, including trackable packaging, packaging delivery and recollection, and customer-owned packaging, among others (Long et al., 2021). Another study on reducing food and packaging waste with a systems thinking approach is on designing self-service food packaging systems by Albach et al. (2018), based on future studies and scenario planning. The authors involve design students in creating postcards from the future, depicting alternative scenarios for packaging and dispensing grain and bulk products (e.g. rice, beans, nuts, seeds, etc). They present the development and testing of a new concept of transparent containers with valves and sensors, which allow the user to choose the amount and pay the price of the product. The concept aims to reduce packaging and food waste, improve hygiene, and enhance the user experience. However, this remains a new area of inquiry in design literature and requires further exploration of the implications of systems thinking and product-service systems in designing and implementing zero-waste food systems.

Considering the main scope of the educational project focussing on sustainability, we adopted a systems-thinking approach integrating various scales of design intervention including, products, services and systems in the form of developing alternative business models. The social sustainability and systems thinking approach as emphasised by Manzini (2015, p. 17) reconsiders the existing production models and proposes the notion of 'distributed systems' by empowering local skills and rethinking the proximity of these systems including products and services to resources and points of demand. The systems thinking approach helps design students *demonstrate the viability and continuity of their design solutions* by considering actors, resources and tools and their interrelationships within a business model. This way of thinking also helps them *incorporate services about sustainability* such as prolonging lifespan, sharing, repair, reuse, upgrade and related service models. Manzini has pioneered incorporating *social sustainability* and *systems thinking approaches* in design education. The design studio education at the third-year level has been influenced by those approaches over the years. The educational project presented here showcases the means of co-developing design solutions in line with their emerging and locally relevant business models.

Educational Case: Zero Waste Food Takeaways and Deliveries Project

The 'Zero Waste Food Takeaways and Deliveries' project was carried out over 14 weeks with 85 third-year students at the Department of Industrial Design, Middle East Technical University, Turkey. The project aimed to empower students to develop sustainable design solutions for takeaway/delivered food in the form of a product family, by re-imagining the entire cycle and experience of stakeholders in the food system for healthy and responsible food production and consumption. Within this framing, the project gave emphasis to students on how to shape sustainable futures in the context of responsible and reduced consumption and zero waste. The students were organised to work in teams (20 teams of four, one team of five: 21 in total). Two main design considerations were embedded into the brief:

1. Promoting sustainable food practices and healthy eating habits and behaviours, with sub-dimensions of *zero waste packaging*; *zero food waste*; *personalisation*; and *behaviour change*.
2. Supporting local resources and local know-how, with sub-dimensions of *local businesses*; and *local know-how and tastes*.

The brief also introduced two kick-off business models relevant to the sector:

- ‘Borrow-A-Container Takeaway/Delivery Service’ (BAC) describes a business lending reusable containers and accessories to customers. This model requires the business to invest in a suitable reusable product family (or else lease it from a third party) and to prepare their food and drink for customers accordingly.
- ‘Bring-Your-Own Container Takeaway Service’ (BYOC) describes customers who bring personally owned containers and accessories to food outlets and ask sellers to fill them with food and drink to take away.

Teams were expected to design a service system taking one of the business models as a starting point for their ideation. They were then required to design a product solution fitting within the service system. The product solution was expected to take the form of *a family of food and drink containers/accessories*. Individual components of the product family were encouraged to have variation and differentiation, such as using different volumes, combinations, and surface finishes, suited to different needs and contexts. The containers were required to be made from glass, ceramics, metals, or natural fibre composites. No restrictions were placed on materials for accessories (such as cutlery, serving aids, lids, bags, etc.), which needed to suit a wide range of functional and experiential needs. While designing product solutions, the student teams were expected to give attention to coherence and aesthetics, since the product family should integrate well with the overall business model and service design. The project was managed across the following main stages:

1. *Literature review*: Online and offline resources were used to develop baseline familiarity with a range of assigned topics relevant to the brief, including materials, food safety, trends in healthy eating, food container accessories, and solutions for portability and storage.
2. *Hands-on food experience*: Takeaways were created for various food categories (e.g. appetisers, salads, stir-fried veggies, hot meals, bakery), with teams documenting their experiences of preparing, presenting, packing, transporting, serving, and cleaning. Outcomes were shared in a class workshop, contributing to the creation of a pool of project resources.
3. *User research on takeaways*: Interviews were made with small-scale business owners/staff and customers on the university campus focusing on the food experience. Observation notes were generated for food preparation, display, serving, and storage, and potential design issues were identified.
4. *Preliminary jury*: Using 3D mock-ups, sketches, and drawings, teams presented their in-development business model, service design, and product family, for formal critique.

5. *Final jury*: Using three presentation boards, a full-scale (1:1) physical model and (optionally) a prototyped mobile application, teams presented their finalised business model and service design, their product family, and technical drawings. Teams were also required to deliver a project process portfolio at the end of the project, documenting their decision-making and the resources they had used.

To help teams in their systems thinking, three tools were introduced sequentially through the project: networked business canvas model, scenario building, and conceptual prototyping and co-design.

The *Networked Business Canvas Model* is a design tool that facilitates the exploration and design of alternative business models for distributed value creation networks (Bakırlioğlu, 2022). It is based on the original Business Model Canvas (Osterwalder & Pigneur, 2010), but adds elements to capture the networked nature of businesses, such as the multitude of actors, networked value proposition, diverging and converging materials, and resource and value flows. This tool enables the exploration of involved actors (e.g. customers, restaurants, suppliers, delivery drivers, app/service platform owners, etc.), their capabilities, needs, and preferences, who collaborate and exchange value in complex, networked food delivery and takeaway systems. The tool facilitated an in-depth exploration of the opportunities and challenges for design intervention in the food delivery and takeaway sector by taking the business models as a starting point.

Scenario building is a skill nurtured through design education that focuses on students using their mind's eye to foresee the how, when, why, where and what of their design visions, as well as the potential consequences of design interventions on various stakeholders (Hines & Zindato, 2016). By building and testing out scenarios focusing on various actors in the food systems, the tasks they are expected to perform, and the environments in which they operate, students could reject or refine their design ideas. Scenario building encouraged students to step back from ideating around individual user-product interactions to see the 'bigger picture' of design problems and solution spaces, from multi-stakeholder perspectives.

Conceptual prototyping involves the presentation of preliminary designs that embody design intent, but which are left purposefully incomplete or at a low level of fidelity to encourage critique, interpretation, and modification during evaluation sessions (Lim et al., 2008). For this project, the conceptual prototypes included storyboards, alternative distributed value creation network maps, and physical mock-ups of product family solutions. Each of these prototypes was used to facilitate at least four co-design sessions with stakeholders in food delivery and takeaway systems. Conceptual prototyping and co-design sessions provided a practical-oriented approach to eliciting and responding to the concerns and feedback of multiple stakeholders. Teams were able to determine the efficacy of their preliminary product solutions, service designs and business models within the food systems they explored and make adjustments accordingly.

Results

The systems thinking focus of the project enabled the reimagining of takeaway/delivery services in ways that were quite different from conventions. Project requirements involved the consideration of the diverse needs of the network of stakeholders (including but not limited to customers, couriers, chefs, producers, and food supply chain actors). The following headings describe emerging themes of alternative food delivery and takeaway service design solutions facilitated by systems thinking.

Micro-local delivery and takeaway services

Solutions under this theme conceptualised delivery and collection systems within pre-defined constrained areas or spaces, such as within singular neighbourhoods, in residential towers with a high number of residents, or within university campuses. The rationale behind these solutions was straightforward: to limit the operational area of delivery and collection services to dense enough areas/spaces to economically sustain the businesses.



Fig. 1: 'Zero' borrow-a-container food delivery service for the fitness-minded, by Yasemin Kardelen Akça, Seymur Mammadov, Yonca Sübay and Umut Zeynep Göral.

An example is Team 9's 'Zero' design solution (Fig. 1). This BAC delivery and takeaway business model operates only within a university campus, i.e. an area with a dense population. The team conceptualised operations of multiple stakeholders, i.e. different restaurants and cafes that offer wide-ranging food and drink options, customers consisting of students and university staff, students working part-time in delivery and collection, as well as design solutions (e.g. containers, collection points). In addition to customer journey mapping, the team mapped the projected journey of the reusable takeaway/delivery containers to understand the opportunities and limitations of their

potential design solutions. The final proposal included an application to track on-campus deliveries and collections, and metal reusable containers that can withstand the foreseen wear throughout the container journey. The most innovative aspect of this solution was the flexible involvement of students in the collection system - essentially forming a 'community of collectors' - in order to sustain an effective collection process.

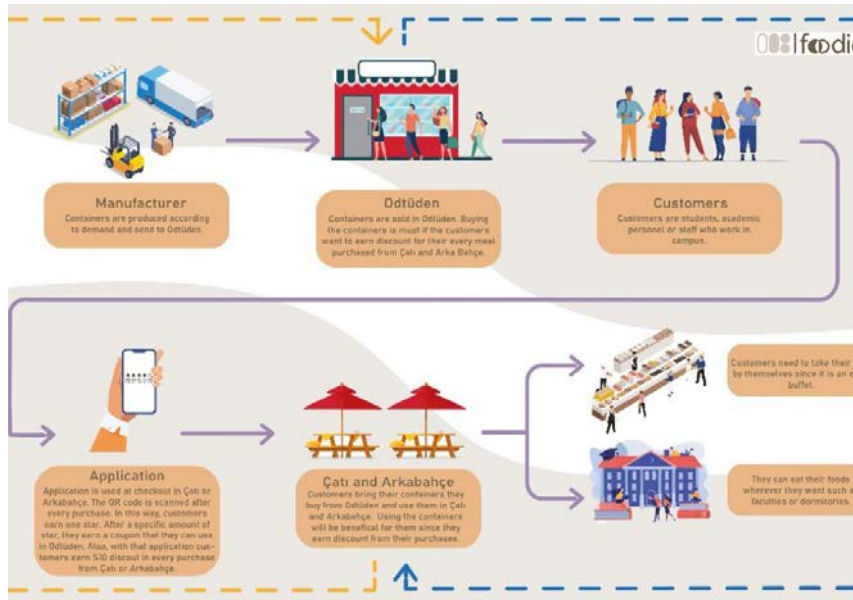


Fig. 2: 'Foodie' bring-your-container takeaway service for the Middle East Technical University campus, designed by Gökay Aydın, İlke Başpınar, Melis Ergün and Merve Nur Sözen.

A similar pattern existed for teams working on BYOC business models, where a standardisation across a dense network of restaurants and cafes within limited areas (e.g. campuses) was also observed. For example, Team 3's 'Foodie' design solution (Fig. 2) involved the sale of standardised reusable containers that can accommodate the wide-ranging food and drink offerings on campus. By analysing the different types of food and drinks available in different restaurants and cafes, the team developed a container range with standardised measurements that allowed universal use across the campus. They also identified sales channels (i.e. METU bookstore) appropriate to the campus community and devised various incentives for adopting the product family.

Third-party container provider services

Solutions under this theme were concerned with the additional resources required to manage delivery and collection services which may not be economically sustainable within the confines of singular restaurant businesses. Students conceptualised alternative service design solutions to the existing third-party delivery services by intertwining two service layers: delivery of food and drink, as well as collection of used

containers ready to be introduced back into the service chain. By managing the container delivery, collection and maintenance (i.e. cleaning, repairing, replacing) on behalf of a network of restaurants and outlets, these external services could be economically sustainable and reduce CO2 emissions by streamlined delivery and takeaway routes, reducing the need for double trips (i.e. a single trip can be used for delivery and collection).

Team 15's 'Soogana' is a third-party provider service solution (Fig. 3) focussing on Asian cuisine with a unique brand identity. The maintenance and cleaning services are provided by this systems-thinking service solution. It also involves a recycling system through which any broken containers are separated and sent to another service provider to reintegrate the damaged containers into the system of production.

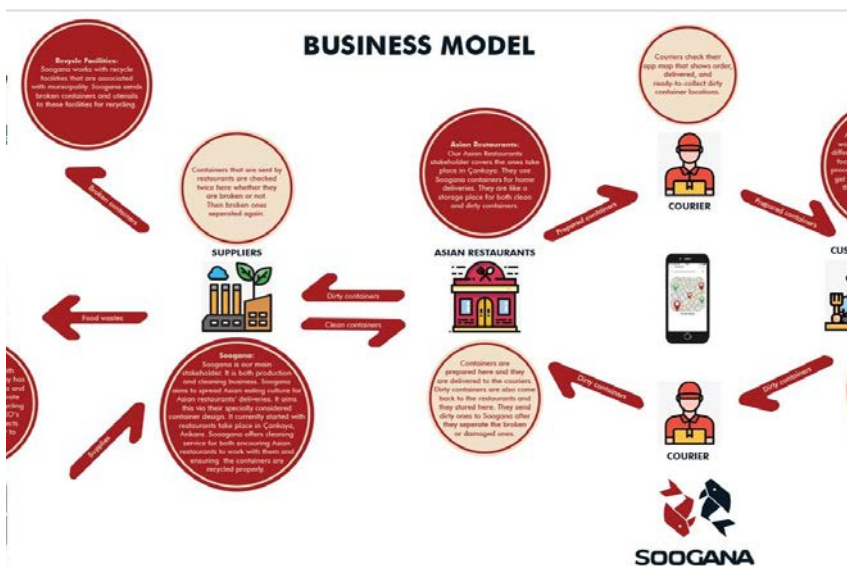


Fig. 3: 'Soogana' third-party container provider service-system solution, designed by Ahmet Aksoy, Deniz Kiyğı, Mervegül Öksüz and Sude Pursin

Team 1's 'Götür' is an example of a third-party container provider service solution (Fig. 4) which provides food and drinks containers to local restaurants. The service maintains and cleans the containers through an integrated system involving a container supplier, a network of restaurants, and individual customers. The solution promotes sustainable transportation modes (e.g. electric vehicles) while delivering and collecting containers. In line with this business service model, *Team 1* proposes a modular and personalised container solution, through which individual components could be brought together in different configurations depending on the needs and preferences of local restaurants.

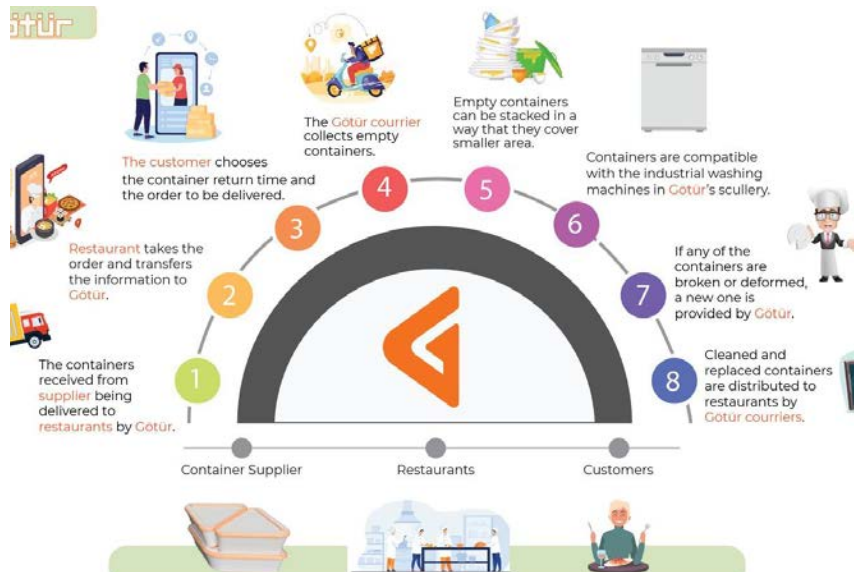


Fig. 4: 'Götür' third-party container provider service-system solution, designed by Afra Sevil, Barış Balkan, Ceren Keklik, Raziye Zalgı and Zeynep Nur Hasripi.

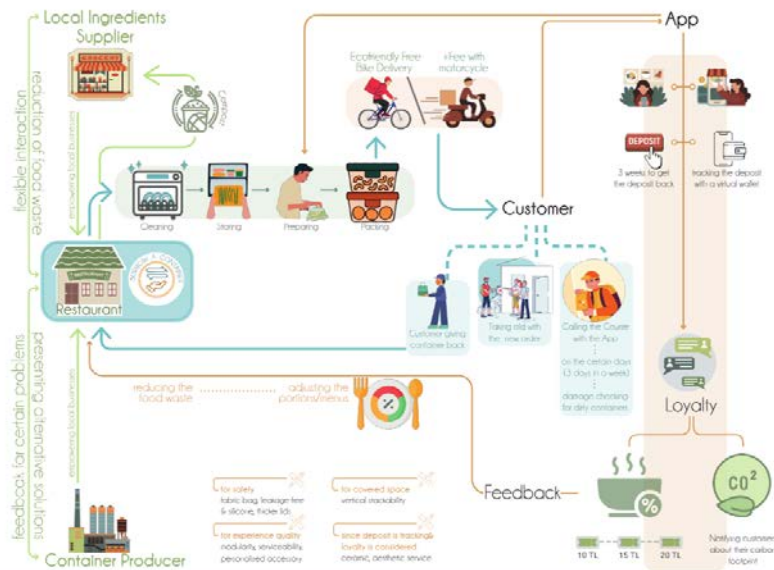


Fig. 5: The system map of 'Mitterra' borrow-a-container food delivery service with diverse stakeholders, designed by Beyza Eylül Ergün, Demet Çamlı, Melis Uludağ and Sudenur Ortak.

Implications of systems thinking in designing zero-waste deliveries and takeaways

Team 10's 'Mitterra' is an example of a more complex systems-thinking solution that involves diverse stakeholders and presents the relationships between them, including

local ingredient suppliers, the container producer and the local restaurant adapting a BAC food delivery service (Fig. 5). Within this business model, an app design solution demonstrates how the system could be sustained in the long term by applying loyalty schemes promoting sustainable behaviour choices (e.g. choosing an eco-friendly bike delivery option, informing users about their carbon footprint, providing feedback to the restaurant on food waste, adjusting the portions). Team 10's solution is a good example of how deploying a systems thinking approach can enable the conceptualisation of food systems beyond the immediate focus of the project, i.e. expanding into food delivery services and facilitating the development of more holistic sets of design interventions.

Table 1: Analysis of systems thinking and design solutions.

Team	BAC	BYOC	Micro-local delivery and takeaway services	Third-party container provider services	Observation on System Thinking
1	✓	–	–	Offers containers to local restaurants, managing delivery, collection and cleaning.	Eco-friendly delivery via electric vehicles; customers choose container collection time.
2	✓	–	Pick up food with containers in a specially designed bag.	–	Containers available at market; customizable, discounts for BYO customers; promoting local farmers.
3	✓	–	Eat-in or pick up food with containers in a specially designed portable bag.	–	Containers produced to demand for sale at campus shops; usable in all eating places with discounts for customers bringing their own; earn additional coupons via app for more discounts/freebies at campus shops.
4	✓	✓	Pick up food with containers arranged for portability.	–	Borrowers return items to designated 'return bins' on campus for collection by the shop for cleaning, scanning them with a QR code; earn a free coffee with a loyalty card: buy five, get one free.
5	✓	–	Online orders only, motorbiked couriers deliver within a 10km radius.	Unified delivery, collection, and cleaning service.	Endorsement of local food producers; customers receive deposit refund upon container returns.
6	✓	–	Campus-based; order through the app for pre-prepared food pickup or eat-in at temporary office-like space.	–	Endorsement of female farmers in the local district; container collection by café staff at office doors, done on foot and guided by app notifications.
7	✓	–	Order via app, delivery by courier.	–	Locally owned farm for seasonal, homemade food; partnerships with local workshops & factories for packaging and containers; 2-day container return period, free collection; food waste as fertiliser; in-app promotions.
8	✓	–	Order food via app from contracted restaurants.	Container rental agency with courier service, providing delivery, collection & cleaning.	Containers can be kept for a limited period if food is not yet consumed.
9	✓	–	Campus-based: main delivery, by courier companies, assisted by students at pick-up points.	Delivery from local restaurants via couriers to campus pick-up points; returns by customer, courier, or students.	Customizable portions; monthly food waste-saved info; app-based container tracking for deposits; student incentives.
10	✓	–	Order food via app for bike delivery or pay a fee for motorbike.	–	Local groceries for plant-based food supply; virtual wallet tracking for deposits/returns; incentives for loyal customers; carbon print info provided.
11	✓	–	App-based restaurant/food selection for self-pickup.	–	Discounts for new container buyers and BYOs; reducing unnecessary waste; cleaning by the customers; supporting local producers; environmental awareness.
12	✓	–	Campus-based restaurants' food delivery to campus area.	Courier delivery; manufacturer (separate company) responsible for repairs and cleaning.	Returns by customer to designated stations; app-based container tracking;
13	✓	–	Order food via app from multiple cafes.	Delivery and container collection by electric motorbike couriers via shortest route.	App-based container tracking for deposits; higher cost for deformed and uncleaned returns.
14	✓	–	Order food via app from small food kiosks, where ingredients are supplied externally.	Food deliveries from kiosks to customers by couriers, including container collection.	Customers add finishing touches to food before eating.
15	✓	–	Order food from multiple restaurants.	Food deliveries and container collection by a courier.	Supplier manages container production & cleaning; food waste goes to recycling; damaged containers recycled if irreparable.
16	✓	–	Campus-based restaurant food micro-local delivery with a food cart; food kiosk and mobile track with take-away.	–	Container returns by customers; app-based container tracking for deposits; app-based deposit tracking; loyalty program offers free meals and special deals; local ingredient supply; leftover food collected for composting.
17	✓	–	App-based restaurant/food selection for self-pickup and return.	–	Membership-based daily food box receipt; ingredients from local suppliers; customers receive clean containers when returning dirty ones; container cleaning at restaurants.
18	✓	–	Customers eat in or take away.	Local delivery from orchards via couriers; customers return containers or leave them at collection cabinets for pickup.	Reusable container cleaning and food waste composting by the orchard; app-based reminders for returns.
19	✓	–	Order food via app.	Motorbike courier delivery; returns by customer or courier.	Endorsement of local farmers; warehouse provides containers to restaurants; cleaning handled by restaurants; app-based deposit tracking for containers.
20	✓	–	Pre-order food via website or in-store for take-away.	–	Endorsement of women's cooperative; containers available for purchase individually or as a set with a carrying bag.
21	✓	✓	Customers collect their food.	–	Endorsement of local farmers; food waste used as fertiliser; container deposit refund upon return; container purchase option.

Table 1 highlights the two emerging themes amongst the student projects (i.e. micro-local delivery and takeaway services, and third-party container provider services), alongside the impact of systems thinking in the final design outcomes. Nearly all teams (20 out of 21) adopted micro-scale localisation as their starting point, and developed solutions focused on e.g., business centres or specific neighbourhoods. Some (10 out of 21) reconceptualised and expanded typical third-party delivery services to involve reusable packaging and organised collection. Others reimagined collaboration among small businesses and proposed local business food delivery offerings through food marketplaces or similar. Each of these directions revealed a diverse set of challenges centred on transitioning from single-use packaging consumption to longer-life solutions and implicit changes in professional practices and consumer behaviour. In this way, packaging was extensively reimagined for food preparation, portioning and pricing, food type-specific delivery considerations, durability and compatibility according to the delivery vehicle (e.g. bike, motorbike, on foot), serving at home or office, collection after consumption, and longevity according to maintenance and cleaning processes. Furthermore, the teams generally endorsed local food producers, devised app-based container tracking and deposit management, incentivised loyal customers and container returns, and promoted waste reduction throughout the food systems they conceptualised.

Conclusions

In conclusion, beyond a user-centred approach, the paper illustrates the value to be gained in taking a whole systems thinking approach in educational design projects, with the aim to uncover and respond to the diverse needs and preferences of various stakeholders. One of the main ways to achieve this, which separates the work from more conventional design activity, is the integration of business models into the problem/solution space of the designer. Business models require designers to extend their thinking to practical and entrepreneurial factors that go beyond individual product-user relations, as well as beyond the narratives that surround existing and conventional solutions. The combined use of the networked business canvas model, scenario building, and co-design activities based on conceptual prototypes, provided the students with a powerful suite of tools to deploy systems thinking, which helped them reach innovative and potentially impactful solutions. In the area of take-away food and drinks packaging, the suite of tools allowed students to define and comprehend the 'bigger picture' of opportunities and constraints at play, covering the spectrum of activities for takeaway food and drinks: e.g. ordering, preparing, carrying, delivering, borrowing, serving, eating/drinking, returning, and cleaning/maintenance. In the absence of a systems thinking approach, we predict that design solutions will be more isolated and prone to obsolescence, missing out on the key interactions and long-term opportunities that arise when a network of stakeholders is properly considered.

From an educational perspective, the project provided a practical and structured way for students to understand the necessities and practicalities of reaching sustainable

design solutions in complex systems with various stakeholders, which should provide a good foundation for their professional careers. By intentionally integrating systems thinking into a sustainable design solutions project, the students gained practical skills and developed a better understanding of the issues surrounding single-use food packaging. This also helped them become more aware of the complex relations, needs and preferences of various stakeholders involved in the system, and develop the capabilities to align interests through designing products and services by reimagining whole systems.

Based on our observations, some of the student teams directly benefited from their business model while developing design solutions. Whereas for others, it appeared to be a separate phase rather than an integrated one. We believe this is related to an unfamiliarity with the scale of the solutions involved, which is much greater than the individual product scale that students had been used to. In future projects that aim to address systems-level change, additional design exercises could be planned which aim to develop the two strands (idea generation and business model development) simultaneously through a more interconnected approach. Nonetheless, a valuable outcome and contribution of this educational project was that the student teams were compelled to explore various design interventions beyond physical products (e.g. applications, contexts, spaces), contributing to complex, connected, systems-level design solutions to reflect on the multifaceted dimensions of sustainability.

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CReDit Statement

All authors contributed equally to the conceptualization, methodology, and writing of this manuscript. The author list was created according to alphabetical order based on authors' surnames.

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Do Make me Think - Towards an Integrated Model for Sustainable UX Design.

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ABSTRACT

The paper explores the potential to stimulate more socially sustainable practices in the professional field of user experience design. We argue that the endeavour is mandated by political trends towards the regulation of “deceptive patterns”, rooted in a more general concern with manipulating algorithms, the user interfaces that mediate them and their consequences on the well-being of citizens and their effects on democratic processes. We argue that the project requires challenge of the status quo – i.e. current design frameworks models to “hook” users, that lack some key concepts to help digital professionals confront their practices to comply with societal demands. We strive to incorporate these concerns in a synthesized model directed at stimulating socially sustainable change, for use in design workshops tailored to industry professionals. We acknowledge the paradox and the inherent contradictions in the project and discuss them in the conclusion.

“All models are wrong, but some are useful” – George E.P. Box (Box, 1976)

Introduction: An emerging political focus on social sustainability

In recent years, the concept of social sustainability has gained traction within policy frameworks in Denmark and internationally. Decision-makers increasingly make the argument that long-term societal well-being depends on more than economic and environmental factors, sometimes called non-financial indicators. This emergent paradigm aspires to combine values like equity, inclusivity, community resilience, and social cohesion into sustainable development policies. In practice this means that we see an increase in legislation promoting equitable access to resources, fostering social justice, and ensuring that community members meet their basic needs and participate fully in society. Social sustainability initiatives may encompass diverse issues such as affordable housing, healthcare, education, fair labour practices, and the protection of vulnerable populations. In the United Nations SDG-framework e.g. social sustainability is expressed in goals for well-being, quality education and sustainable communities (The 17 goals, 2022). The inclusion of these principles within policy agendas marks a shift toward a more holistic approach to sustainability that acknowledges the interdependence of economic, environmental, and social systems.

The business side

Besides being a political concern, social sustainability also plays an important role in the ESG-framework, aimed at assisting investors in identifying companies that “*promote ethical and socially conscious themes including diversity, inclusion, community-focus, social justice, and corporate ethics, in addition to fighting against racial, gender, and sexual discrimination*”. (What Is Environmental, Social, and Governance (ESG) Investing?, accessed 14.5.2023.). In a sampling we made of 10 of the most visited web shops in Denmark, it is apparent that many companies have adopted socially sustainable values. Our sampling was guided by the “Sustainability Brand Index” (Official Report 2023 Europe’s Largest Brand Study on Sustainability, 2023), and we visited the five most sustainable brands (according to the report). We found elements of social responsibility in all companies (Rema, Lego, Thise, Coop and Aarstiderne). Elements included communication dedicated to diversity and inclusion, social responsibilities, typically formulated in CSR and compliance reports. See Figures 4-7 in the appendix.



Figure 1 Screenshot from supermarket chain REMA's website, page informing about CSR initiatives (CSR-rapport, accessed 15.2.2024)

Context: action research and other binds

The research is conducted from the Copenhagen School of Design and Technology. One of the diplomas offered at our institutions is a bachelors' degree in multimedia design. A substantial part of the training consists of acquiring competences in UX-design (we will explain this professional role shortly). Its' research ambitions can be explained using terms from the action research tradition. Action research is a form of collective self-reflective enquiry undertaken by participants in social situations to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out (McNiff & Whitehead, 2002)

In contrast to other academic approaches, action research strives to

- try out theories with practitioners in real situations and real organizations.
- combine theory and practice in concrete, tangible and mutually recognizable problems and within mutually acceptable ethical frameworks.
- involve researchers and practitioners in iterative processes, aimed at acting together on a particular cycle of activities, including problem diagnosis, action intervention, and reflective learning – often gleaned methods from design thinking (Romme, 2004)
- Modify theory as a result of the feedback.
- Emphasize true and egalitarian collaboration between stakeholders.

A central tenet of action research is that researchers should be explicit about their approach, clarify their research aim, theory, and method at the outset and all the way through its application, as well as at the time of its publication. A prerequisite for the above, i.e. trying theories with practitioners, combining theory and practice, and involving stakeholders in iterative processes, is to have a guiding model that engages with new questions and new professional demands.

Research question and methodological considerations.

So: the research stems from an action research background, is driven by actors with extensive professional experience, for industry partners and aims at designing processes that intervene in practice. What are the practices that need to be intervened on? In this paper, it is on the field of user experience design. In the following, we will introduce UX design as a profession, argue that some of its practices are under pressure, and take steps in developing a new analytical model, by arguing that the design practices often embedded in action research and design thinking fall short in the light of new demands for social sustainability. In one sense, our project is a theoretical, exploratory, future-oriented, speculative project, aiming at laying the foundations for a new type of practice - by addressing issues that have been underprioritized. Despite its focus on theory, it is directed at grappling with very concrete and practical issues related to behavioural problems caused by dominant rationales in current UX – design, and thus subsumed a general action research agenda.

Research question: How could we develop a model to guide future UX-practice for the support social sustainability – to challenge practices deemed problematic by political organs?

User experience design

"While often at the forefront of expanding material consumption, designers are now increasingly facing the issue of how to achieve the opposite." (Cipolla, 2008)

A User Experience (UX) Designer is a professional who is responsible for creating satisfying or compelling experiences for users of a product. UX designers typically facilitate the design of products that offer a seamless and intuitive user interaction. User Experience (UX) Design is inherently multidisciplinary, merging principles, methods, and knowledge from various fields to create products, systems, and services that provide meaningful and relevant experiences to users. Some of the key disciplines that contribute to the multidisciplinary nature of UX Design are:

- Human-Computer Interaction (HCI): a focus on the design and use of computer technology, particularly the interfaces between people (users) and computers.
- Psychology - understanding human behaviour, perception, cognition, and emotions is essential in UX Design. Psychological principles help designers comprehend how users process information, what motivates them, and how they remember information.
- Design Thinking - a problem-solving approach that involves understanding user needs, challenging assumptions, redefining problems, and creating innovative solutions to prototype and test.
- Information Architecture (IA) - the art and science of organizing and structuring information in products and services to support usability and findability. This involves understanding how user process information and making complex content accessible and navigable.
- Usability Engineering - designing products that are easy to use and match user expectations. Usability engineers focus on quantitative and qualitative methods to measure user satisfaction and performance.
- Visual Design - the use of imagery, color, shapes, typography, and form to enhance usability and improve user experiences, drawing from graphic design principles to create an aesthetically pleasing interface.
- Other responsibilities include include content strategy, anthropology and sociology, computer Science and Software Development, accessibility and inclusion, with an understanding for product management and business strategy.

(Bika, 2017; Soegaard, 2024; *What Are UX Roles?* / IxDF, accessed 13.2.2024.)

The scandal of UX

To outsiders, the profession of UX-designer may seem like an odd mix of disciplines and a somewhat peripheral occupation compared to programmers or more specialised professions like graphic designer or copy writers, but the focus on the effects of UX - design have exploded recently – notably in the context of the Cambridge Analytica scandal in 2018.

"In March 2018, news of the Facebook-Cambridge Analytica scandal made headlines around the world. By inappropriately collecting data from approximately 87 million users' Facebook profiles, the data analytics company, Cambridge Analytica, created psychographically tailored advertisements that allegedly aimed to influence people's voting preferences in the 2016 US presidential election." (Hinds et al., 2020)

Suddenly, our relationship with computers – and the role of UX in that relationship came under intense public scrutiny. One direct consequence of the scandal was a series of public confessions from Silicon Valley leaders and innovators who made startling confessions about their role in developing UX techniques that manipulated with users, ultimately to the extent of threatening democracy, and “destroying how society works” (as Chamath Paliapitiya declared, former Vice President for User Growth, (Karppi & Nieborg, 2021))

At the heart of the scandal were the addictive features that created the preconditions for the abuse of user data in the Cambridge Analytica scandal, and the behavioural design to make habit forming products that trigger desired outcomes built on principles of variable rewards, unpredictable content, and a (false) sense of autonomy – i.e. the feeling that you as a consumer have a degree of control over your actions. These psychological techniques rapidly became standard on social media and e-commerce websites, and built on insights from behavioural economy (Kahneman, 2012), theories of “nudging” (Thaler & Sunstein, 2009) and communicated through practical guides in how to hook the user (Eyal, 2014) or designing solutions that prevent the user from having to think (too much) (Krug, 2013).

These techniques, come from a position that focus exclusively on commercially preferred actions and share a reductive view of the user as a target of manipulation. One example, the “Hook Model” (Eyal, 2014) - figure 2 - below, divides the flow into four phases:

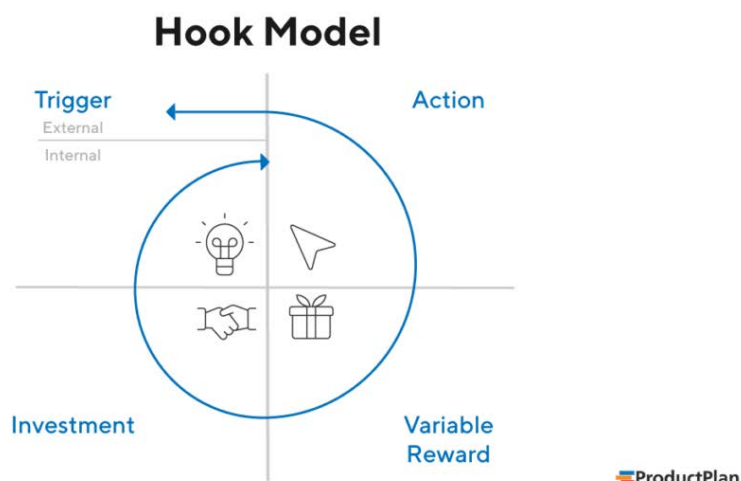


Figure 2 – The hook model from “Hooked” (Eyal, 2014)

Trigger: something intriguing that calls for an action.

Action: the behaviour done in anticipation of a reward.

Variable Reward: the exciting juxtaposition of relevant and irrelevant sets the users' brain "dopamine system aflutter with the promise of reward".

Investment: "An action that improves the service for the next go-around".

Another example of a popular approach to UX-design can be found in Steve Krug's "Don't make me think" (Krug, 2013). Steve Krug himself labels his approach a "common sense" one. Communication online should be "...self-evident. Obvious. Self-explanatory". As a rule, he continues "people don't like to puzzle over how to do things". He then proceeds to demonstrate how the average user is irrational and inattentive.

These two models have been widely adopted, wildly successful and have driven innovation in the field at an impressive pace. But one could also argue that they have been the driving force behind unwanted behavioural changes at a huge scale.

A European political trend – democratic interventions

"Deceptive design patterns aim to influence users' behaviour and can hinder their ability to effectively protect their personal data and make conscious choices." (EDPB, 2022)

The Cambridge Analytica scandal, the confessions of former Facebook CEOs and the public outrage over the manipulation of users, and films like Netflix's "The Social Dilemma" (Orlowski, Jeff, 2020) were probably instrumental in different political initiatives to regulate UX-patterns that risked compromising users' data and undermining their well-being.

In 2022, the European Data Protection Board (EDPB) published guidelines on how to recognise and avoid deceptive dark patterns (in the context of GDPR regulation). EDPB is a legal entity, that has the mandate to ensure "consistent application and enforcement of data protection law across the European Economic Area" (*Tasks and Duties / European Data Protection Board, 2024*)

The guidelines have three target groups:

"...social media providers as controllers of social media, designers and users of social media platforms on how to assess and avoid so-called "deceptive design patterns" in social media interfaces that infringe on GDPR requirements."

EDPB defines considers deceptive design patterns as

“...interfaces and user journeys implemented on social media platforms that attempt to influence users into making unintended, unwilling and potentially harmful decisions, often toward a decision that is against the users’ best interests and in favour of the social media platforms interests, regarding the processing of their personal data. Deceptive design patterns aim to influence users’ behaviour and can hinder their ability to effectively protect their personal data and make conscious choices.”

EDPB categorises deceptive design patterns into six categories:

- Overloading
- Skipping
- Emotional Stirring
- Obstructing
- Fickle
- Left in the dark

In this context, the patterns share the fact that they contribute to breaches in GDPR-principles - put in place to protect citizens’ data. The patterns prompt users to share more data than necessary, make it harder to manage data, make people forget about data protection aspects etc.

The report – 73 pages long – ends with an interesting take on “best practices”, which could be useful as a guideline for the development of “user-loyal design practices”, later. They consist of 19 principles, among them:

- Providing contact information for datacontrollers and supervising authority.
- Coherent wordings.
- Providing definitions.
- Explaining consequences of different choices.

The report is a testament to how seriously this subject is treated, and a strong indication of how current practices are being regulated.

Deceptive design also goes under the name of “dark patterns” According to a mapping by Colin Gray et. al (Gray et al., 2023) dark patterns can be described as “tactics of technology manipulation”. They have become pervasive in a range of digital services and “regulators are beginning to act in banning the most aggressive practices under consumer protection and data privacy” (p.1.). The scholarship about dark patterns “started as a small trickle within the HCI-community”, to “more than two dozen publications per year starting in 2021”. It is not within our scope in this article to conduct a full literature review on the dark patterns-scholarship, but according to Gray et al. it is still subject to scholarly debate, “which types of patterns produce the most harm” and “how regulators and legal professionals should identify (and sanction) the use of dark patterns”.

A Danish trend – a whitepaper and expert recommendations

In Denmark, the government has recently published two different reports (in 2022 & 2023), that signal a paradigm shift in political perceptions of IT. Historically, the government, through policy papers, strategies, white papers etc. has made the case that it was important to digitize as many processes as possible – resulting in increased IT-budgets, education, awareness campaigns. Before 2022, staying within the realm of political literature it was practically impossible to discern any negative perspectives on IT.

In 2021, however, that changed, with the governments' publication of "Towards a better society with tech-giants" (our translation (*Mod et Bedre Samfund Med Tech-Giganter*, 2021)). In the preface of the publication, it is stated that big tech, and their pervasive technologies, has become a challenge to our democracy. We are standing in front of challenges in health, law, media, tax and as consumers. The report puts forth 9 principles that should guide our use of technology in the future:

1. The business models of tech-giants should be under democratic control.
2. Children should be able to have a secure childhood in a good balance between the digital and the physical world.
3. Tech giants should support democratic dialogue instead of creating echo chambers and polarization.
4. Tech should giants, should to a higher degree be made accountable for the content on their platforms.
5. Free media should contribute to the democratic dialogue and creatives should be paid for their work.
6. The right of workers should be protected.
7. Tech-giants should contribute to society like all other companies.
8. Competition should be fair and transparent.
9. Democracy should decide on the frame for tech, not the other way around.

In the report, each item on the list is developed, often with reference to phenomena stemming from UX practices that (are considered to) cause addictive use of media, polarizing debates due to algorithmic logics (giving people more of what they want instead of what they need) and so on.

In 2023 the ministry of Business, published "Democratic control with the tech-giants' business models (our translation (Flyverbom, 2023)". Many of the themes from the 2021 report are echoed in this report, in the form of recommendations grouped under 4 headings, and several sub-categories.

- Limitation of data-harvesting and clearer choices
- Limitation of tech giants use of retention mechanisms
- Limitation of tech giants endeavour to predict and influence behaviour.
- the responsibility of tech giants to guard children from inappropriate content

Again, the document is addressing a range of phenomena, that would be unthinkable without a range of UX-practices that manipulate users to act in a way that is deemed counter-productive to collective and democratic ideals.

These three documents are just a few examples of a new sensibility in policy: this concern, especially for how the user and his/her data is extracted or used against the users' will is visible in large, all-encompassing frameworks like GDPR, the digital services act and the digital market act that have had a huge influence on businesses, and of course on the requirements for new UX-solutions – e.g. to ask consent for cookie-practices to name one well-known and ubiquitous feature of websites since GDPR was introduced.

In the light of these institutional developments, the role of the UX-designer is challenged:

"While often at the forefront of expanding material consumption, designers are now increasingly facing the issue of how to achieve the opposite." (Cipolla, 2008)

A sustainable model for UX-designers

The field of UX-design has had a narrow focus of reducing friction for commercial interests, based on a one-dimensional view of who the user is, and what she ultimately wants. This envelope has been pushed to the point where loyalty towards the user has been compromised, in favor of tactics that work against conscious choices. If we accept the notion that deceptive designs aim is to override the users' initial intention (buying a plane ticket, ordering a seat at a restaurant e.g.), we suggest a model for UX-analysis and design, that broadens its perspective, and incorporates dimensions that comply with recent political foci. In this model, considerations about user behaviour, competitive edge and new potentials created by technological development, are infused with legislative, epistemic, and value-driven concerns from non-commercial actors: research institutions, educational institutions, and NGO's (figure 3). The model situates the different dimensions on a spectrum between deceptive and loyal poles. These are not binary states – but acknowledge that working with these issues in practice, is a matter of moving incrementally in one direction or another, rather than permanently switching to one preferred state over another.

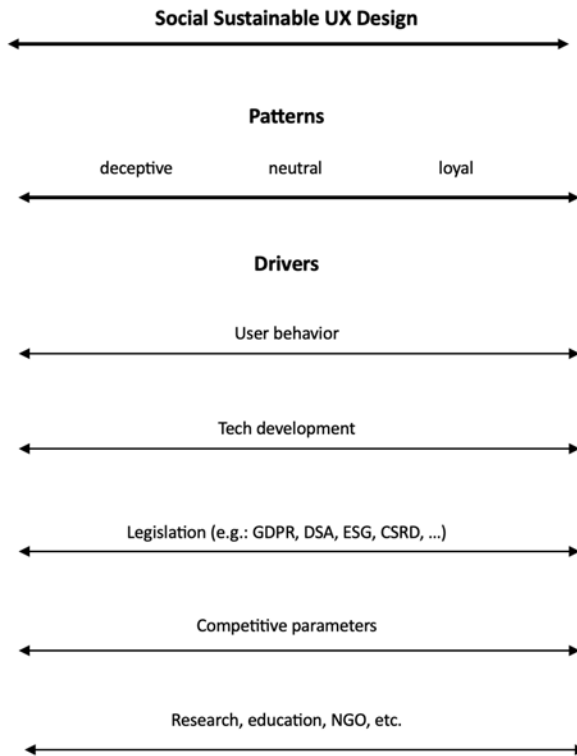


Figure 3 – the SSUX model

The model aims at expanding the parameters for the UX-designer, and at supporting the intentions of the rational and attentive consumer. This is a person who has a desire for products (a) in a sustainable tech environment (b), that complies with policy (c), that has a competitive edge (d) and whose consequences/values are supported by research and knowledge generated by NGO's (f).

A unified model of social sustainability in in UX: planning for future practice

In the section above (context and other binds), we described our commitment to action research. In one sense we did not live up to the principles, by taking steps backwards into modelbuilding. To compensate, we will describe how we could test the insights derived from the work with integrating political demands into a design model, into a concrete practice. The target audience is UX Designers, Product Managers, UI Designers, Interaction Designers, and could include typical design thinking concepts like user persona templates, prototyping materials, workshop handouts and the deployment of Sustainable value Business Model Canvas or similar frameworks.

Content	Purpose	Potential benefits
The communication of case studies where socially sustainable products has improved user experience.	To make the argument that the project has validity	To persuade participants of the realism of the project
Information about the EU data protection boards guide on how to identify deceptive design patterns.	To inform about legal developments	Heightened knowledge
To map instances of deceptive design practice in the stakeholder's own practice	Discover legal vulnerabilities	Self-awareness
Integration of EDPB's best practices (clear contact information, coherent wording, sticky navigation, cross-device consistency, explaining consequences etc (EDPB, 2022)).	Mitigate against legal vulnerabilities	Concrete action
To evaluate the impact of sustainable techniques on user behaviour and business models.	To gauge the realism of the project	Development o sustainable business models

Conclusion, discussion, and perspectives

In this paper we asked how we could support social sustainability in the UX-professions. We made the case that political attention has made the question relevant, and that it is a discursive phenomenon in mainstream company communication. We proposed a unified model for socially sustainable UX design to understand that challenges dominant models by Eyal and Krug, to confront and mitigate the negative effects of current practices. The aim has been to develop a method to stimulate reflection and start innovation-processes that align with emerging political demands. A unified model aims to develop more thoughtful and loyal design patterns. The model needs to be tested, and the next step is to develop methodical research on potential interest for products that are free from data-extraction, deception, and manipulation.

The scope has been narrowly professional and has avoided the larger philosophical and political discussions about the premise for doing business inside capitalist frameworks: as long as financial growth is tied to an increase in sales and revenues, as long as increased sales depends on extracting data from the user (Zuboff, 2019) it seems improbable that UX – practices that work towards creating obstacles for sale, and that reduce the data-economy could have any measurable success.

On the other hand, changes in consumer demands sometimes create the push for commercially sustainable offerings, even when they go against the grain of adopted business logics. Examples can be seen in the tourism industry, e.g. offering holidays for digital detoxing/austere products like silent retreats, functions that ask the user to rethink actions (when Microsoft Outlook gives the user the possibility to cancel the sending of an e-mail)

Another big flaw in this paper, is the lack of empirical knowledge about the prevalence of the models that we claim are at the basis of most UX-practices. We basically don't know whether professionals are integrating legal requirements and ethical consumer demands into their practices.

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Appendix: documentation of top sustainable brands' commitment to social sustainability

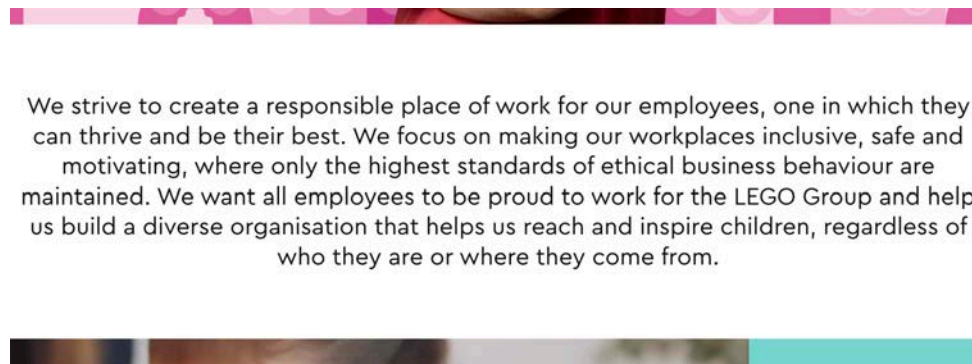


Figure 4 – LEGO sustainability page about people (People - Sustainability - LEGO.com, accessed 14.5.2024.)

- Klimavenlig emballage. Thise mejeri anvender i videst muligt omfang genanvendeligt materiale i emballagen og laver detaljerede emballageopgørelse. I 2023 traf vi beslutning om at udfase plasticlåg på vores samlede konsummælkssortiment. Med virkning fra Q1 2024 vil plasticlågene være helt udfaset.
- Reduktion af dieselforbruget til mælkeindsamling og køletransport, samt indkøb af virksomhedens første 100% eldrevne kølelastbil.
- Trivsel på arbejdspladsen. Igen i 2023 har Thise Mejeri arbejdet målrettet med at skabe en bedre arbejdsplads for alle, ligesom vi er fokuseret på at inkludere medarbejdere med vanskelige vilkår, herunder ukrainske krigsflygtninge.

Vi er stolte over at vi i 2023 har taget flere store skridt i vores arbejde med Ordentlighed, men anser det også som forpligtet at vi i 2024 sætte yderligere fokus på dette område.

God læselyst med vores 2023 rapport om "Ordentlighed".

Figure 5 – Quote from Thises "Ordentligheds"-rapport (CSR-report) (Ordentlighed - Sådan Tager vi Ansvar, 2023). Translation: "Well-being in the workplace. Once again in 2023, Thise Dairy has worked focused on creating a better workplace for everyone, and we are also focused on including employees with difficult conditions, including Ukrainian war refugees."



Styr på arbejdsforhold i Sydeuropa

— 2019 —

Arbejdsforholdene er ikke lige gode alle steder i verden. Det kræver ekstra opmærksomhed, og Coop stiller nu krav om, at de sydeuropæiske leverandører af frugt og grønt skal certificeres efter Global Gap Grasp, så de sociale risici forbundet med for eksempel migrantarbejde bliver sat ned.



Figure 6 - (Nielsen, 2020) Translation: "Labour conditions are not equally good everywhere in the world. This requires extra attention, and Coop is now demanding that southern European suppliers of fruit and vegetable suppliers to be certified according to Global Gap Grasp, so that the social risks associated with, for example, migrant labour, are reduced."



S4

Social and Employee Conditions

Diversity and Inclusion

In total, we are more than 50 different professional competencies and 12 nationalities in one place, and the talk at the lunch table stretches out in a lot of different directions and is definitely not boring.

All managers in Aarstiderne work with a social, economic and sustainable responsibility, a purpose that is written directly into Aarstiderne's articles of association and has been part of Aarstiderne's business since 1999. It is therefore clear to all managers that Aarstiderne has a significant positive impact on society and the environment as a whole and that as a leader in one's daily work and decisions you must act accordingly. In all job postings, Aarstiderne draws attention to our diversity policy.

Figure 7 – Aarstiderne: Diversity and inclusion (Bohé, 2023)

Design of a Co-evolutionary Approach for Sustainable Educational Ecosystems

Anders Berglund, Mälardalen University

ABSTRACT

Navigating societal, technological, and environmental changes, the urgent need for transformational change within organizations and society has become a paramount concern. The sustainable development goals (SDGs) necessitate innovative approaches that can address complexities and multiple-actor involvement to enable systemic shifts. This paper highlights the urgency of quality education SDG #4 as a trigger point for educational change action. This paper seeks to explore how design thinking can be systematically linked with transformational change and theoretically contribute as process enabler as part of an educational ecosystem. Through actuators, change agents, change processes and reasons for addressing this from a systems perspective is conceptualized in an educational ecosystem. By delving into co-evolutionary dynamics of organizational complexities, this paper looks for ways to establish more resilient strategies for change that also in for future work can further inspire to align efforts with the SDGs.

Keywords: sustainable education, educational ecosystem, change agents, design thinking

Introduction

Although there is a myriad of ways to utilize design thinking (Razzouk and Shout, 2012), educational research efforts provide several important perspectives, e.g., constructivist learning (Scheer, Noweski, and Meinel, 2012), innovation capability (Berglund, 2013), that imply linkage towards new educational design imperatives (Berglund & Leifer, 2016). In order to affect and impact change mechanisms, the awareness of partnerships and how interconnected parts form a system has increased in importance for learning societies, as this is a process built around sharing and participation (Niemi, 2016). The ecosystem concept has emerged across many disciplines, and is creating impact in different forms (e.g., business, innovation), still as the increase and need for an industry 4.0 perspective raising in attention, a holistic learning system is being more frequently addressed (Koul & Nayar, 2021). However, it is more the capability of designing this in a seamless form that argues for the term educational ecosystem, which encapsulates the intricate network of elements encompassing individuals, contexts, and components involved in the teaching and learning process. In this paper, the argument toward a more robust framework takes notion of learning happening via relational processes as system elements. The ways in which elements operate in dynamic interrelation with each other cause multiple critical dualities to be constantly explored. As such, this ecosystem, much like a living entity, thrives on a cyclic interplay between problems and

solutions. Drawing upon inspiration from co-evolution design theory (Gero, Kannengiesser and Crilly, 2022), this paper adopts a lens that perceives context variables, e.g., function, behaviour, and structure, as important aspects impacting educational ecosystems. Framing a theoretical framework, the paper emphasizes transformative actions undertaken in higher education, by utilizing design thinking attempts (Calavia, Blanco, Casas, and Dieste, 2023), and extending new insights by broadening the organizational perspective (Kwon, Choi, and Hwang, 2021).

From capabilities to ecosystem

Although there exists an apparent urgency beyond academia to grow innovation capabilities, the implication for a systematic leverage of skills is still little researched (Berglund, 2013). While research in higher education focuses on forms for senior management support, systematic and strategic actions to attain a competitive edge have placed greater emphasis on knowledge sharing, capacity building and innovation capability (Lo & Tian, 2020). Thus, the utilization and practice provide reasons for a meta perspective to strengthen the impact level of design thinking as mechanism for change. However, rooted in a critical perspective of pragmatism, 'Design Thinking' has been argued to provide undergraduate students with an unrealistic idea of design and the work that goes into creating positive change. Upending the traditional saying "knowledge is power," design thinking educators provide their students power without knowledge, "creative confidence", yet without building upon design capabilities to realize innovation (Vinsel, 2017). This concern causes claims that design thinking is a mere formula for success, a brand by itself, prompting some researchers to intensify application of design thinking practice (Laurson and Haase, 2019), as well as further engraving the design practice across disciplines (Lake, Flannery, and Kearns, 2021).

The cultivation of smart educational environments is built upon circularity between reusing existing knowledge and framing this in both virtual and physical form (Gros, 2016). Realizing an educational ecosystem hinges on the ability to instigate change through diverse avenues. The combined utilization of bottom-up and top-down change approaches has received attention as important facilitating change mechanism (Berglund, et al., 2015; 2017)s; this paper recognizes the imperatives of the synergistic potential between these change directions. A pivotal facet of this collaboration involves establishing avenues for meaningful dialogue and empowerment. By systematically supporting change agents as actuators for change, the educational ecosystem can strengthen a culture that embraces innovation. The paper emphasizes that facilitation and intraorganizational collaboration necessitate a structural approach that goes beyond the individual.

Design thinking as change enabler

In contrast to overarching, formulaic papers scattered with design thinking as a buzzword, it is evident that design research has coalesced around a genuine design theory (Dorst, 2011; Cash, 2018). It simultaneously expands application areas by further

explaining and readdressing the ‘designerly’ way of designing (Cross, 2023). Designers engage in open-ended and emergent steps, continually proposing, evaluating, and rejecting possibilities for change and disruption. While research demonstrates the importance of establishing an innovation culture to embrace new processes, utilizing core design thinking practices deepens the array of possibilities that potentially could emerge as actions, and post-actions. This is where design practice provides an opportunity for value to excel, especially in addressing the pressing needs of organizations when conventional problem-solving falls short (Dorst, 2011). Systematic approaches that enable scalable redesign escalation using design thinking remain sparsely represented or documented in academia (e.g., Calavia et al., 2023; Kwon, Choi, and Hwang, 2021). Placing educational change in a larger context has been proposed earlier, yet many times the expertise being institutionalized, embedded in the organization, has difficulties in properly surfacing on occasions where suitable. Although many educational systems need change, only a fragmented number of these systems present any systematic support structure (Graham, 2012). Adopting a systems perspective situates teaching and learning within a stakeholder scenario, emphasizing the need to harmonize functions and outputs in an ecosystem.

Change frameworks

Change frameworks related to higher education, and engineering education such as those presented by Henderson, Beach, and Finkelstein (2011) and Borrego and Henderson (2014) provide important insights. While strategy, and policy function more explicitly to guide steps forward, what is referred to as solution and shared vision concerns later stages, requiring more mature reasoning or actions to have unfolded. Despite its major implication on results, organizational culture entrenched in the values of productivity, perfectionism, and siloed specialization can easily establish friction in the adoption of design thinking within an organization. More general frameworks targeting essential cultural incentives for enabling change (Elsbach & Stigliani, 2018), serves to identify a number of avenues for future research that might advance our understanding of design thinking in organizational contexts.

Still, several catalyzing factors enabling a systematic approach for change remain untold. Wieman and Perkins’ (2005) rudimental physics education redesign approach has inspired several initiatives, where bottom-up initiatives have gained important traction (Viberg, et al., 2019, Berglund et al., 2017). Approaching change strategies with the objective of establishing systematic changes to courses requires considerations for resource allocation and human resource management (Chasteen et al., 2015).

Mastering change in higher education is a formidable challenge, marked by its inherent complexity, in need of multiple perspectives that require a strategic intervention (Fullan, 2007). To enable change, directional awareness is crucial among decision-makers, serving as a catalyst for facilitation and change occurrences, either from a bottom-up or top-down approach (Högfeldt et al., 2018; Berglund, et al., 2017). This process influences a culture of change through different encounters of authority (Kezar and Eckel, 2002).

By exposing a directional approach, the role of change agents can support decision-making at various hierarchy levels. Past research delineates the use of multiple types of change agents, operating at different scope, targeting pedagogical actions at either individual, departmental, or organization level (Viskupic, Earl and Shadle, 2022). As change agents are purposely used to mitigate the gap between top-down directives and bottom-up initiatives, integration of design thinking aligns needs with the emergences of novel pedagogical approaches and the progressive nature of the educational landscape. Change agents play a crucial role in facilitating successful educational transformation by proactively enabling change agents and fostering an innovation culture that can facilitate more sustainable actions. Building a supporting culture that embraces educational innovation is therefore deemed critical to alleviate concerns and resistance that stakeholders may have, increasing the likelihood of successful adoption and sustained outcomes. The design approach for instituting change emphasizes the necessity to enhance transparency while concurrently infusing sufficient grinding efforts.

Purpose

The purpose of this article is to delineate the components of a sustainable educational ecosystem and elucidate how design thinking can serve as a vital conduit for transformative actions. Drawing on insights from literature and prior projects focused on educational change propositions (Berglund et al., 2015; 2017), higher education transformation (Graham, 2012), and operational steps to determine factors for cyclic educational refinement Högfeldt, et al. (2018) concerning program development and the actions by leaders in program courses, it identifies important areas requiring attention. Unveiling the gaps in an educational ecosystem model could support design thinking research, contributing with theoretical frameworks that connect educational change, change agents with design thinking.

Methodology

This paper synthesizes literature at the crossroads of research and practice, examining their convergence for the improvement of educational ecosystems. Google scholar and Web of Science was searched to find relevant literature targeted using keywords; sustainable education, educational ecosystem, change agents, and design thinking. To further determine the relevance of articles assessed, a preliminary screening for relevance was done. Designed as a position paper, collected experiences and past research have been used to motivate the practical implications of the theoretical framework. The collected experiences are characterized by course analysis connected to an engineering design program made up by documented course input and reflections, and by screening educational research projects, a comprehensive model emerges from the narratives and experiences shaping change initiatives. Pursuing how Lo and Tian (2020) link different forms of knowledge captures, this research considers teachers' course notes, teaching plans, and course analysis, as well as more embedded aspects such as teaching experiences, and pedagogical skills. The framed model encompasses

insights gathered and discussed over a 15-year period, focusing on sustainable higher education change reforms. It sheds light on the dynamics of change actuators and their role in either facilitating or hindering decision-making actions.

Discussion

Committed people have long been recognized as crucial for driving change and its ensuing impact. This paper introduces an educational ecosystem framework rooted in the well-documented double diamond framework of design thinking, illustrated in Figure 1. The framework distinguishes how individuals and organizations can iteratively progress through stages such as explore, define, create, catalyze, and refine. Simultaneously, it considers individual engagement and the alignment of separate actions with leadership and organizational empowerment, fostering an interplay resembling the agile capacity building of modern universities. This approach cuts across multidisciplinary attempts, addressing root causes at a foundational level. Whether initiated prescriptively by the organization or emerging organically through self-driven, eager, and dedicated employees leveraging networks and possibilities to empower good ideas, these individuals are important change actuators. While applying design thinking at the program and course levels highlights contexts in transition, Taimur and Onuki (2022) suggest that curricular repetitive interception addresses essential building blocks for reframing new perspectives on teaching and learning. However, Calavia et al. (2023) emphasize that support for a more sustainable representation of design thinking is still lacking and fragmentarily represented at the university level. This underscores how change using design thinking necessitates a broader application, potentially affecting domains beyond the given course or program at hand. Incremental refinement is an approach towards embracing this ethos. In an increasingly competitive higher education landscape, there is a growing focus on linking sustainable governance with an overall strategy, emphasizing the utilization of internal capacities. Establishing internal collaboration efforts that foster cross-disciplinary exchanges and interests is therefore a prime concern for internal growth and knowledge sharing. This systematic process aligns such actions is aligning with Lo and Tang's (2020) assertion that both local and global connections provide a basis for innovation capability. The design thinking framework reinforce organizational capacity building towards innovative solutions by addressing solutions as part end point, but equally important the beginning for refined iterations.

By drawing upon the co-evolutionary framework presented, Figure 1 presents a perspective that highlights the interconnectedness of context variables and their alignment with SDGs. The proposed model can support the refinement of sustainable outcomes in higher education and associated processes. The model is organized into five distinct phases: *explore*, *define*, *prepare*, *create*, and *catalyze*, originating either from a prescriptive mission or an emergent vision. It delineates actions toward a synergy of bottom-up and top-down activities, crucial for cultivating an environment conducive to educational innovation. Establishing change impact, the model posits that vertically

integrated change agents are critical enablers in this ecosystem, leveraging co-creative efforts toward subjects of concern. While the design phases also correspond to ‘problem space,’ this forming phase is also where ‘Strategy’ needs operationalization. As actions progress toward a ‘Solution,’ the ‘solution space’ is less fixated on immediate deliveries but drives further in-depth validation praxis forward. This way, the ecosystem establishes resilience beyond domain interests, aiming to enable a generative value that transcends individual stakeholder demands. Over time, by engaging actuators of change, individuals acting as change-agents may shift away from short-term gains motivated by snap-shot spreadsheet indications, moving toward a deliberate intention to create an intersection for further design practices. Design thinking literature offers diverse frameworks for comprehending and implementing design thinking in various contexts, with Laursen and Haase (2019) suggesting their placement in categories based on the level of activation, focusing on process, perspective, or organization.

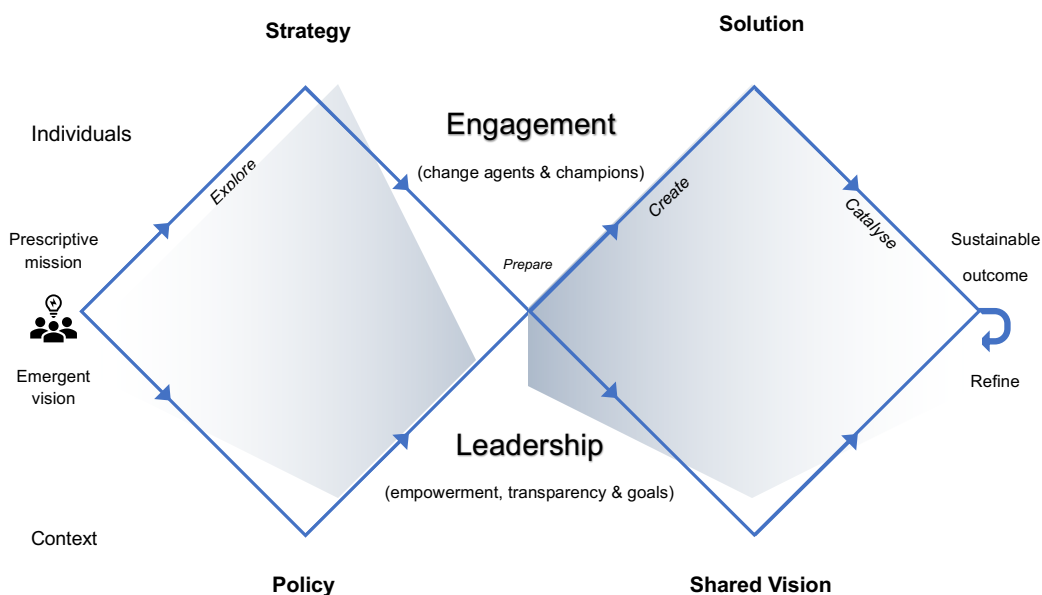


Figure 1. Design model of an educational ecosystem.

Within the problem space, encompassed by strategy and policy, it is crucial to facilitate boundary-spanning activities. These actions enable individuals to feel less pressured in exploring arising direct or indirect needs emerging from students, colleagues, or course analysis. The depth of exploration is influenced by framework practices, occasionally constraining efforts or hindering the desire to extend beyond existing patterns.

Reframing possibilities, two distinctions—“engagement” and “leadership”—sometimes encounter vague or even deceptive policies, and, in combination with a lack of clear strategies, unfold challenges in decision-making, coalition formation, and the formalization of engagement. The paper posits that both motivation and persistence by

champions remain crucial for achieving change. To assess and value not only the elements of the ecosystem but also to further define actuators, i.e., the points targeted for change that will impact the given context and the interconnected flow of unfolding events. Thus, it becomes critical not only to initiate actions properly, as good practices and attempts may emerge through need-finding processes, but also to support and enable opportunities that contribute to the resilience of cyclic value streams at stake. This cyclic progression exhibits similarities to Kolb's (1984) experiential learning cycles, representing the process steps stemming from embedded needs and inspiration to ideation and implementation (Brown, 2008). From an operational level, dynamic interaction and feedback loops are embedded in the model, enhancing adaptability and learning capabilities within the system. A notable aspect is derived from how Wieman et al. (2005) captured the essence of highly motivated internal sponsored employees, dedicated to improving numerous aspects related to teaching and learning. From a systems perspective, this involves mixing people rooted in different disciplines and those that has not necessarily worked together before, establishing cross-disciplinary teams that can nurture and establish relevance for value creation beyond the domain-specific returns from any investments made.

Champions, driven by a deep commitment to their cause, may find the system either too narrow or too vast, hindering self-sustainability of initiatives. Finding a meeting point for these champion and leadership actions is crucial to harness the full capacity of the organization. The impact of change extends beyond thematic influences; to illustrate local transformation efforts, insights from Kezar and Eckel (2002) on operationalizing higher education can be applied. Mälardalen University (MDU) exemplifies wide-ranging initiatives that align strategic concerns with embedded disciplinary knowledge domains. The goal is to establish more than a few rings of occurrences, not only for strategic interest but also to create long-term roadmaps guided by change agents. To facilitate this, four distinct positions have been recently established: 'Fundamental AI,' 'Applied AI,' 'The impact of AI on society,' and 'AI in higher education' (MDU, 2024). An important consideration for this initiative is its basis for initiation—whether it follows a prescriptive mission or is built on an emergent vision. The educational ecosystem can fuel actions and guide how unfolding initiatives are channeled down the vertical lines of the context in which traction is sought. To improve overall capacity, change agents are used in the form of acting independent, interconnected with stakeholder interests, policy and gatekeeper passages. Additionally, how will the strategy associated with this initiative realign with policy implications, and if so, what should be the feasibility of reconsidering the execution and delivery of existing practices? At this stage, it is challenging to provide definite answers to these emerging questions, and speculation is inevitable. However, this nuanced situation extends beyond immediate technological challenges, as evolving concerns about impact have the potential to significantly reshape our approach to and processing of actions. Design thinking has evolved, and according to Cross (2023, p.8) the educational ecosystem is well situated in an emergent new form, that acts "within complex, problematic issues... towards a competency, a way of thinking

and working that embodies a broader form of strategic, adaptive, co-operative intelligence for engaging with wicked problems.”

Moving towards an integrated practice, designerly thinking, adapts and extends how governance and influence built-in to the complexities of organizational dynamics. This is affecting cognitive patterns as a tentative blueprint, also impacting structures, and disciplinary domains, as borders are blurred, and it becomes more important to process and uncovering value gaps, exploring needs, and realizing potential benefits. The way design thinking unlock interaction, is beyond local domain-specific concerns, it is a ‘modus operandi’ that breath progression. The iterative approach and openness operate from a losing up, smoothen, and resolving friction in the educational ecosystem. Striving to address an urgency of change while also considering the immediate operational impact, cross-disciplinary expansion places thematic impact as a solution-oriented aspect. By framing contextual support as the foundation for a conceptual approach and assessing this research, the study contributes novel insights into transformative and sustainable change efforts in academia. Directly aligning with SDG #4, quality education, and echoing the emphasis on output concerns by Lake, Flannery, and Kearns (2021), while design thinking assumes a pivotal transformative role in bridging complexity challenges for large organizations (Dorst, 2011). Amid uncertainties, the potency of change efforts is fortified by merging research disciplinary practices, where awareness and strategic positioning serve as guiding elements for sustainable educational transformation.

The presented educational ecosystem framework contributes to theory that interlinks innovation, and organizational change from a designerly point of view. Improving and creating more transparency to the interlinked stakeholders (e.g. entities, departments, positions, or regulations) also mean that partnerships, and processes could be further redesigned, potentially affecting more than formal functioning. In this educational ecosystem, change agents provide according to Högfeldt et al. (2018), the factual level of inclusion and empathy to provide important design elements for how nodes of the ecosystem perform. The outline and design process aims to comprehend diverse stakeholder interests. Yet, what’s often less explicitly addressed is the articulation of their needs and the utilization of narratives, as these are emerging forms of initiatives. The implementation of new changes, as suggested by Borrego and Henderson (2014), involves navigating the inherent complexities of higher education change processes while striving for innovativeness. Effective leadership is required to balance between amplifying the impact of change and managing disruptions caused by external conditions or the need to disrupt existing work practices. By presenting the categorization of direction for change agents and emphasizing the motivation for change, the use of design thinking for academic change focuses on course or program development rather than on a systematic institutional level. As Elsbach and Stigliani (2018) suggests a strong culture is fundamental to make use of connected patterns, especially acceptance and sharing within an ecosystem is to expand. Although Kwon,

Choi, and Hwang (2021) found that large organizations tend to segment the design thinking process, and not necessarily dealing with the whole process, due to the complexity of dealing with multiple stakeholders. Due to such a fragmented approach by large organizations, higher education institutions need further anchoring of what could support systematic improvements. The educational ecosystem views progression flows a vital mechanism in the interaction between stakeholders. Despite the leadership importance to drive this, the suggested three-step phase by Kwon, Choi and Hwang (2021) characterized by roles and responsibilities and the ability to creatively prototype and test proposals is inadequate. Design thinking can support in this case the combination of both strategy and operations. Leadership value is built around making use of resources available, creating spin-offs through moderation of funds, and time. Today, the educational ecosystem needs impactful revisions due to game-changing challenges and opportunities. Especially those reconsideration of actuators, leveraging points, and beneficial partnerships is increasingly making room for new agendas. The way industry 4.0 is affecting industry, is causing a major upset for the educational ecosystem (Koul & Nayar, 2021), as this also provides the adoption of generative artificial intelligence and potential redesign of fundamental practices for teaching and learning.

Conclusions

The paper serves as an important link to envisage a sustainable educational ecosystem that not only adapt to change but proactively strengthen the theory-building trajectory for design-driven educational change. The presented design model of an educational ecosystem represents a convergence of disciplinary perspectives, emphasizing the pivotal role of key individuals as influencers in driving change process. Harmonizing isolated change mechanisms is, in turn, part of a long-term visionary endeavor, continuously refined to establish a functional operational and strategic sync. The essence of innovation extends beyond mere proposal presentation and internal political navigation to secure favor among decision-makers. Fostering awareness and transparency of process influences calls for a value-driven approach that goes beyond the sheer abundance and quality of potential alternatives, serving as direct reflections of their relevance and desirability in the innovation ecosystem.

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Food Sharing as a Community Design Approach

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ABSTRACT

This article explores the issue of building communities while considering the positive impact of food-sharing behaviour as a main principle to reduce food waste. Food sharing is one of the approaches to reducing food waste (FW) that aims to share surplus food for re-consumption before it becomes waste, and the sharing activity strengthens communal relations between people by supporting design for social innovation (SI) approach. In our methodology, we combined literature review and practical data. First, we categorised the attempts to manage FW through SI under four categories: food banks, dumpster-diving, monetary reuse through digital platforms, and food sharing. For the methodology of this part, we visited a food bank in İstanbul, interviewed a dumpster diving community in Poland, and evaluated a digital platform that activates monetary reuse. We discussed these attempts by looking at four criteria: revenue for the organisation, involvement of digitalisation, physical design areas, and community building. Then, by adding a designer lens, we analysed the activities of food-sharing communities within the Food Supply Chain (FSC) by comparing the examples around Europe. Finally, we proposed a PSS design and discussed it through four Sustainable Development Goals (SDGs 1,11,12,17) to reinforce the adaption of food-sharing behaviour to food-saving behaviour in daily life through community building.

Keywords: food-sharing, food waste, community building, design for social innovation

Introduction

The current food system in the world, called Food Supply Chain (FSC), directly affects food waste (FW). The food industry and food distributors, such as markets, grocery shops, restaurants, charity organisations, etc., are examples of chain links that greatly impact FW. In all likelihood, in FSC, more than 33% of the food produced is wasted (United Nations Environment Programme, 2021). The rapid consumption development of the last century and the beginning of the current one has had a significant impact on the environment and can result, among other things, in unsustainable lifestyles. In 2022, the UN announced that the planet's population was 8 billion people; by 2050, the projected number will be as high as 9.7 billion (United Nations Department of Economic and Social Affairs, 2022). It should also be noted here that at the beginning of the 20th century, it was around 250 million (Ljungberg, 2007). In response to problems of food-related behaviours and processes that cause FW, we decided to look closer at the issue of

increasing the efficient usage of produced food by sharing and adopting this behaviour by creating communities.

Considering FW as a *hyperobject* -a nonlocal, timeless, and viscose issue (Morton, 2013)- we need small efforts to work as a snowball to create a global effect, as Klein et al. (2016) state that SI can trigger social transformations. Therefore, we worked on finding connections between SI and FW. We saw the high potential of sharing surplus food (SF) for re-consumption before it becomes a waste, and the sharing activity actually strengthens communal relations between people. Accordingly, food sharing is a crucial behaviour to reduce waste, increase food security, and spread social inclusion (Schanes & Stagl, 2019). Moreover, food sharing supports food rescue, a crucial point for FW reduction (Warshawsky, 2015), as making this a common behaviour within a community encourages a sustainable behaviour pattern.

One of the influential figures for Design for Social Innovation (DSI), Ezio Manzini (2014), defines SI as *“a process of change emerging from the creative re-combination of existing assets (from social capital to historical heritage, from traditional craftsmanship to accessible advanced technology), the aim of which is to achieve socially recognised goals in a new way.”* Chiffoleau and Loconto (2018) described SI as creating awareness of social challenges and assisting citizens in finding solutions by looking at the evolution of social change. Hence, DSI has become a critical approach for design scholars considering the effect of social change. We aimed for a bottom-up and incremental transition against FW with food sharing. For the case of radical changes, country-level legislation for reducing food waste can be applied, and this affects food sustainability (Agovino et al., 2018), as bottom-up and top-down approaches to FW involving all FSC stakeholders are tailored in some EU countries (Ghini et al., 2020). Rovati and Pesenti (2015) state that regulations cannot respond to the food system's main stakeholders by addressing society's significance in the issue of FW. There is no general agreement on the societal effects of food assistance activities, and there is no globally accepted framework (Vittuari et al., 2017) for both governmental and non-governmental organisations.

This article explores the issue of building communities with the effect of food-sharing behaviour. Here, we benefited from the DSI perspective since there are different approaches that we can consider as SI to intervene in the FSC, and food sharing is one of these approaches to reduce FW. We first performed a top-down literature review, starting from FW and continuing with the intersection of SI and FW. Finally, we described building unities through food sharing as an approach to managing FW through SI. We evaluated the cumulative findings from a design perspective and discussed how design could reinforce and adapt food-sharing as a food-saving behaviour in daily life through community building.

Managing Food-waste through Social Innovation

FW is not a problem that one could solve alone; it requires communal force to deal with. Hence, utilising SI against FW has the potential to be a credible method for supporting

sustainability in FSC (Lombardi & Constantino, 2020). Building and modifying networks with SI raises the possibility of cooperation from other stakeholders. Ghinoi et al. (2020) state the different stakeholder relations during FW management, such as information exchange, resource sharing, and working together for project improvement. Thus, it can be deduced that the attempts to manage FW through SI require a systemic design approach that considers stakeholders and networks sustainably.

Attempts to approach FW through SI have been divided into five categories by Lombardi and Constantino (2020): food redistribution activities, food rescue, food donation after the best-before-date, food sharing, and volunteerism in non-profit organisations. We conveyed a similar approach and categorised the attempts to manage FW through SI under four categories: (1) Food Banks, (2) Dumpster-diving, (3) Monetary re-use through Digital Platforms, and (4) Food sharing. To better analyse (1) Food Banks, we visited a Food Bank Facility, *Beylikdüzü Gıda Bankası*, and interviewed a manager from there. For (2) Dumpster Diving, we performed an online interview with a member of the Polish Facebook group *Freeganie Kraków*; and for (3) Monetary reuse through digital platforms, we analysed TooGoodtoGo (TGTG) through watching user videos, reading research articles and reports about this organisation. Ultimately, we discussed how these three attempts relate to (4) Food Sharing and which approaches can inspire food-sharing organisations.

Food Banks

Food banks are one of the main approaches that are improved to address public food assistance (Bazerghi et al., 2016). A food bank can be defined as an “organisation *that acquires donated food, much of which would otherwise be wasted, from farms, manufacturers, distributors, retail stores, consumers, and other sources, and make it available to those in need through a network of community agencies*” (Global Foodbanking Network, 2016). We communicated with organisations and visited a Foodbank facility supported by the municipality of Beylikdüzü, İstanbul (Figure 1). That allowed us to understand the system better. Actually, this Foodbank represents a service that collects the SF and distributes it to the people in need. Hence, the food bank we visited provided direct food through its facility and indirect food through the soup kitchen. Creating this kind of organisation saves a huge amount of food from being wasted and helps tons of people who are in need of food. To receive food, the needers should apply to the food bank, showing proof that they do not have enough financial support. Since the organisation deals with lots of political and legal issues, they have to filter applications to define who is actually desperate for food.



Figure 1: The Food Bank's exterior appearance

Visiting the facility also helped us to understand the points where design can intervene in the FSC. First of all, the food banks' interior design is like a market where the needers select and fill their bags with goods, and at the end of their journey, they are given a bill for how many points they spent (Figure 2). Hence, this design does not allow people to communicate but makes it more like a market space where people gather and leave the food.



Figure 2: Interior design of a Food Bank similar to a supermarket

The food bank created a point system in which every registered family or person has a certain number of weekly points, and just like a price tag, every good has a point etiquette. However, in cases where the food bank has excess food that is going to expire soon, they distribute it to the families rapidly through a messaging system. The food service can also be interrogated because, based on the interview, we found that most needers do not have enough expertise to utilise the food efficiently.

They have a solid organisational structure, and we created the system map of the food bank to understand where “design” could participate (Figure 3). The food bank gathers the food from the markers and volunteers; they do not pay anything for either; they gather SF from markets, and volunteers donate the food to support the organisation. The

municipality gives financial support to the workforce and regulates this organisation. The distribution of collected food from the bank can occur in three ways; first, needers can come to the food bank to gather the food directly. Second, if the food is about to expire, they send it to the soup kitchen to make it cooked food, and as a last option, they send the food to animal shelters. Hence, their intention is not to waste food as an organisation and to use SF to prevent FW.

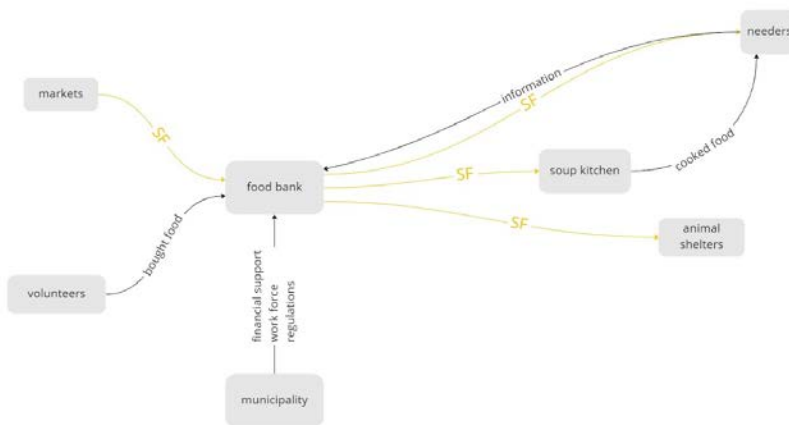


Figure 3: System Map of Food Bank (created by the researchers)

The journey of SF within the food bank system also creates interesting interactions in terms of food culture and knowledge. For example, the foodbank that we visited stores a variety of food and other goods from different markets. These markets sometimes sell brand new products as an experiment to add them later and create new assortments, such as limited imported foods, exotic foods, seafood, or any food that most Turkish citizens would not have in daily food practices.

Another approach similar to Food Bank is the example of Solidarity Fridge, Solikyl (2022), a Swedish initiative that supports localisation while redistributing the SF. Solidarity fridges of Solikyl are spread around the city of Gothenburg first, allowing access to food recipients and providers. With their digital platform, they spread their influence all over Sweden.

Dumpster-diving Networks

The term dumpster diving is generally used for retrieving items, in this case food, from dumpsters for consumption (Eikenberry & Smith, 2005). The main idea behind it is to refuse the creation of FW by taking immediate actions. According to the dumpster diving network interviewee, *Freeganie Kraków (Freegan)*, they do not gather more things through their activities as they care mostly about waste. The only "network" is probably created only by a Facebook group; as the interviewee says, *freegans* (community members) exchange information on every topic in this space, and no leader is involved.

There are no phone notifications or specific apps, and the movement is not popular enough to make one. They gather food by 'skip', which is searching through dumpsters for decent food like vegetables, dry food (pasta, beans, rice), bread, canned food, and pre-prepared sealed meals or sandwiches. S/he states that they do not collect beautiful items, but food is food. Every explorer decides on their own if the food is still available to eat; the interviewee compares the shelf life of food to the warranty date of the refrigerator or vacuum cleaner and the expiration date does not discard these goods immediately after the warranty period, hence they use them as long as possible. Money is never involved in the process; the main point is saving food. They would rather spare the food that they gather by group or friends.

Although Freegans can be sued by a shop as a lifter, and that happened in the past, usually, the cases are won by Freegans. Still, the freegans may receive a fine (collection penalty) if the owner of the restaurant/shop does not allow collecting.

Monetary reuse through Digital Platforms

To explain another approach against FW in terms of SI, we have chosen to explore one of the world's most active digital platforms that allows SF to redistribute to users for a lower price. Indeed, digitalisation affected the manner of building social and economic value around food sector (Michelini et al., 2018). Toogoodtogo (TGTG) is an organisation that sells SF at a discount price through a digital app. The app was launched in 2016 and is considered a leading app against FW (Vo-Thanh et al., 2021). The app connects restaurants and grocery stores (businesses) with users. Their impact area is defined as Europe, but they are trying to expand worldwide.

TGTG co-operates with supermarkets, bakeries, and grocery stores. Of course, for some businesses, the main motivation is not saving the planet; hence, the con of giving SF is not having to deal with SF and making money. For the newly founded places, it also creates an opportunity to increase the frequency of customers. The size of businesses varies from a chain restaurant size to a small coffee shop. The needers go directly to the restaurants, grocery stores, etc., to take it, and they are not allowed to bring their food during rush hours. For the issue of SF, it is hard for some people actually to buy or use it, and Vo-Thanh et al. (2021) conducted a study on TGTG to understand the success and social, functional, and emotional values behind it. They explored the effect of value-in-use, perceived value, and customer value proposition.

TGTG uses design to reduce FW in several ways. Hence, they demonstrate a good example of design intervention areas such as creating awareness about FW, adopting food-saving behaviours, and using these to make an impact on a societal level. According to Thant et al. (2021), they use effective titles such as "anti-food waste," "get good food," "X meals to save," and "every second, 51 tons of food are wasted" which are involved in most of the app's media. Even though what they do is not food-sharing, their aim is to help society adopt food-saving behaviours through their digital platform, and they attempt to manage FW through SI in numerous ways.

The app is the system's main production that connects the users and the businesses on a common ground. Moreover, unlike many other attempts, the app also helps the organisation to work globally. The digitalisation of such services is crucial for SI attempts to spread their effect worldwide. Furthermore, they support the digital app through other channels like Instagram and YouTube; thus, they actually build a digital community that motivates people to behave against FW. Additionally, they diffuse knowledge about FW through their blog, recipes, ways of saving food, and other sustainable behaviours. Moreover, since they want to spread food-sharing behaviour in schools, they designed educational material to create awareness for different age groups.

The attempts against FW, like games in schools, blogs, and Instagram posts, are needed because there is a lack of knowledge about how to use SF efficiently, especially when the food type is unfamiliar to the food recipient. However, when we checked out the blog and YouTube channel, we realised they were not up-to-date. And even though their educational material idea is good, their applicability depends on many factors. Hence, policies can support the spread of educational materials for children.

We saw that the restaurant delivers the food within a magic box (doggy bag), and in this case, the SF is unknown, and whatever the business puts in the bag for a reduced price. van der Haar and Zeinstra (2019) state that even if the TGTG users did not like the content, they would not see it as a problem; they either compost the food or give it to the animals. We understand that these users are highly informed and voluntary in reducing FW. However, this concept may not work the same way for other types of users. Other than that, the businesses that work with TGTG deliver the food to the recipients in a doggy bag, and this is an area where the physical design is involved, and it can be enhanced through analysing the needs of the receivers. Hence, the user groups can be enlarged to people who are not keen on saving the planet but care more about eating cheap food.

In their impact report (TGTG, 2021), their labelling design "Look, Smell, Taste, Don't Waste" project is mentioned; they tried to intervene in the packaging design by increasing the given knowledge on expiry dates. This includes a direct design intervention to products. Hence, we consider that this knowledge about expiry dates can be shared through communal activities.

Van der Haar and Zeinstra's (2019) case study on TGTG supports these by adding the awareness created on not just FW but a general awareness about sustainability. Moreover, we deduced another social impact that the app developed, which is that the users are not just those who need to buy. Mostly, their main motivation is to reduce FW by using the app (Thant et al., 2021). Hence, TGTG helped these people find a way to fight for a common value. We think there is a gap to be filled by society to see SF as consumable, and the app seems to work positively as an indicator.

Food Sharing

Food sharing is an approach to solving food waste using SI. It gives producers, distributors, and individuals opportunities to find a place that is in need of SF. The food products find the needers instead of spoilage through food sharing organisations. Food sharing is considered as an activity that means more than just sharing the food and it has positive effects on society, politics and economy (Martin et al., 2019).

Mackenzie & Davies (2019) categorised types of sharing as sharing the “stuff, skills and space”

The food sharing practices has a positive effect on reducing food waste (Morone et al., 2016) and based on analysis on the food sharing platforms, food sharing can have a significant impact especially in terms of environmental and social sustainability (Michelini et al., 2020). Octavia, Nasution and Yudoka (2022) argue that the essential issue of food sharing is at the micro-level, while the majority of the work focuses on the problem from a macro perspective. Hence, they proposed to enhance the efficiency of food sharing by engaging the concept of collaborative consumption. Michelini et al. (2018) divide the food-sharing models into three categories: sharing for money, sharing for charity, and *sharing for community*. *Sharing for money* is a business-to-consumer (B2C) model in which food businesses both monetise and reduce FW; hence it is similar to the approach to TGTG. *Sharing for charity* is a business-to-business (B2B) and consumer-to-business (C2B) model in which non-profit organisations collect food from any type of provider, which is similar to *food banking*. *Sharing for community* is a peer-to-peer (P2P) model in which consumers share food with other consumers in a local context with no revenue.

Discussion on Attempts to Manage Food-waste through Social Innovation

Figure 4 demonstrates how food banks, dumpster diving, and other organisations intervene in the FSC. Some of these attempts to manage FW through SI also build communities and we can benefit from their approach while discussing food sharing in detail.

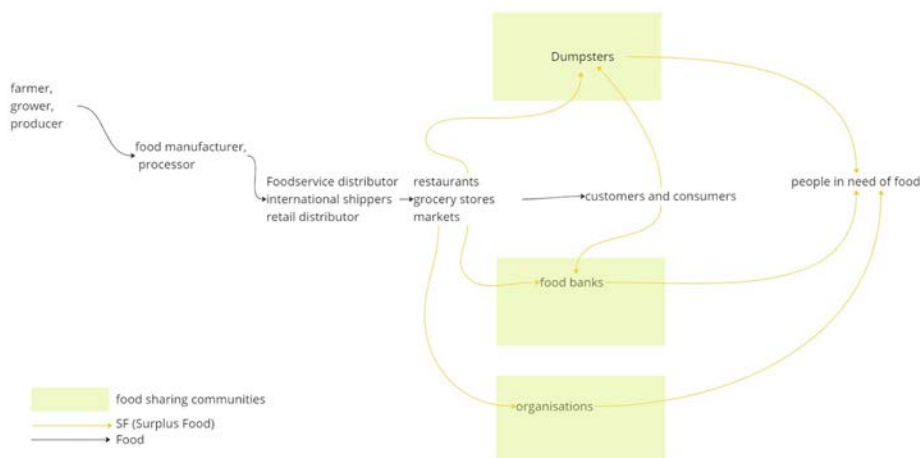


Figure 4. Food banks, dumpster diving and other organisation's role within the FSC

In Table 1, we compared the three attempts to manage FW with SI: Food Banks, Dumpster Diving Networks, and Monetary reuse through Digital Platforms, and discussed how they might inspire food sharing. While only Monetary reuse through digital platforms involves revenue for the organisation, the involvement of payment may affect the system in a positive manner since the businesses prefer it since it also creates a financial opportunity as well as a marketing one. Digitalisation is expected to create more opportunities to fight against FW as well as encouraging food sharing (Davies et al., 2017b) through new forms of sharing (Davies et al., 2017a). Indeed, digitalisation is involved in all three attempts but for different purposes. For example, Foodbank connects with the food donor business through an app, while the app of the organisation (Monetary Reuse through Digital Platforms) connects the food businesses and the users (food recipients). On the other hand, the example Dumpster Diving Network exists solely on digital platforms. Food Banks have many design intervention areas, both interior design and product design, since their current design does not direct all stakeholders to interact with others. Dumpster diving can have some physical design areas by exceeding the borders of digital platforms. The attempts to utilise Monetary reuse through Digital Platforms can be intervened by designing a “doggy bag” in which users are encountered with their food. The current Food Bank design does not allow community building, while other platforms allow it only digitally.

Table 1: Attempts to Manage FW through SI

	Revenue for the Organisation	Digitalisation	Physical Design Areas	Community Building
Food Bank	-	App (between providers and food businesses)	Food Bank Animal Shelter	-

Soup Kitchen				
Dumpster Diving Networks	-	+	-	Sense of community through digital platforms
Monetary reuse through Digital Platforms	+	App (between users and businesses)	Doggy Bags	Sense of community through digital platforms

Building Communities through Food Sharing

In this section, we discussed the organisations that build communities around food sharing in Europe. We involved the communities that were at least active in the last year, and we determined this through web pages and social media accounts. Identifying the actors within this network is a principal issue to understand to engage design within this issue. We also analyse the participant's point of view. We collected the data from the organisations' research articles, websites, and social media accounts. Ultimately, we proposed a system map for an effective food-sharing community design.

Beyond its edibility food signalizes emotional and communal values as sharing and offering food creates bondage and intimacy between members (Davies & Legg, 2018; Hamburg et al., 2014). The fundamental position of SI for decreasing FW should be designing a community with FSC stakeholders' participation to find useful SF areas and prevent FW (Lombardi & Constantino, 2020). Octavia et al. (2022) state that the basis of food-sharing practice utilises Social Practice Theory (SPT), their reason for that based on the individual behaviour practice being the tiniest part of the pattern of social practice. This matches our goal since we also aim to spread the patterns of food-sharing behaviour to adapt to society on a larger scale.

In the research project of Lombardi and Constantino (2020), they utilised SI for FW to build an online food-sharing community for P2P exchanges, create networks between waste areas and needers, and establish educational activities to create awareness about FW. Berns et al. (2021a) utilise queueing as an approach to enrich food-sharing activities. They (2021) mention *Foodsharing-Copenhagen's* approach to FW as an example of activism. Hence, they define the activity of food sharing not just as feeding people but as creating awareness about FW. They point out that the way food sharing works should not be reflected as a *supermarket* where people get the food and leave and they emphasise queueing as a space for interaction between the community to create awareness and discuss FW. Moreover, they discuss the design of the queueing setting. This study inspires us to discuss the importance of physical interactions for managing SI.

According to the collected data (Berns et al., 2021b), the openness of Facebook SF communities emphasises a lot of participants. Even if events are organised mostly by

volunteers and they are mostly benefiterers, many individuals also show up. It is an activism - *food is - and should be - gifted to anyone*. While it may look like it is for people in need, it is not; the main point is to reduce FW by SF. New participants say that the 'first-time event' opened their eyes, and they became more aware by being given education. Organising events about the actual food distribution system seems to empower people to change their lives to be more sustainable. This fact also defines impact as a community; the bigger they are, the more they can save.

Foodsharing.de

Foodsharing.de is a German free food-sharing platform with thousands of cooperating companies in Austria, Netherlands, and Switzerland (*Foodsharing.de*, n.d.). The main goal is to halve food waste by 2030 and then eliminate it. To achieve this, their mission is to shed light tangibly and visibly on the current problems of the globalised world economy and the insanity of the wealthy society, and incite a rethinking. *Foodsharing.de* makes the problems of the globalised world economy practically tangible and thus stimulates a real rethinking. In addition to knowledge about climate change, environmental destruction, global exploitation, hunger and poverty, they aim to show how to take concrete action and truly value food. As a result, practical changes in everyday behaviour towards more sustainable consumption are encouraged and implemented. They write petitions, are in contact with politicians, give interviews and go to demonstrations. The aim is to initiate enlightenment, rethinking and responsible action on a personal and political level. In addition to national educational work, they organise many decentralised workshops on the topics of sustainability, healthy nutrition and food waste, offer joint cooking events and discussion groups and hold lectures and readings. They promote networking through joint actions with other sustainability initiatives in large and small towns and increasingly in rural areas, for example, through neighbourhood groups, urban gardening campaigns, bicycle demos/critical masses, swap shops, repair cafés, information stands, festivals and many other connections. They believe that food sharing brings people from diverse backgrounds together and encourages them to participate, think for themselves and use Earth resources responsibly. The commitment to food sharing goes far beyond simply saving food. The organisation thrives on the fact that people contribute their strengths and interests in a variety of ways.

Food is gathered and distributed to everyone through the *Foodsharing.de* website and volunteers' network. Firstly, the shared products must be checked by hygiene rulers described in the "food hygiene guide". Non-food and medicine products are excluded from sharing and exchange. Platform also enables food to be shared directly with other people in the community; someone posts that he has food to spare, and the deal is done as soon as others accept. Another way to share food is to leave it in "distributors" which are fridges nationwide, allowing everyone to share and take.

Jadłodzielnia

Polish Food Sharing Community *Jadłodzielnia* provides a space where everyone can enjoy or help themselves with food such places for dining or specially marked fridges and appearance. The first *Jadłodzielnia* was established in May 2016 in Warsaw. Today the network is all around the country. They are opened in various parts of the city, e.g., at universities, dormitories, and bazaars. There are approximately fifty places created by this community, mostly in Warsaw. Shops, restaurants, and individuals are encouraged to share SF. Everyone can help themselves to get food, regardless of their material status - it is not an aid initiative. The organisation operates entirely on a voluntary basis. Everyone is allowed to share the food that they will not be able to eat. There are some rules to follow: only food that you would eat, products close to or one day after the expiry date, food must be packed regardless of whether it is cooked or not, and opened dry products should be repacked. Though fresh meat, eggs, and open packages are unwelcome, everybody uses the storage at their own risk (Foodsharing Polska, n.d).

Food Sharing As

Food Sharing As, a local initiative in As, Norway; makes agreements with grocery stores to collect SF (Spire, 2022). They are looking to find common values and see how they can enable people to meet on the same page. They collect food from an area, the community refrigerator, and sometimes they come together to make food using that collected food waste, believing this is an effective way to build a community around food. They facilitate meetings and have positive conversations around food. Hence, they do not want this area to become just a kitchen but rather an exchange area of knowledge, culture, and other values. They collaborate with universities to draw more attention because they think university students may need food and provide help to the community as well. Through this community kitchen, they must make the SF taste and look good. If they just gave the raw food, it would be similar to a food bank. However, they process the food together and spend time there, creating a bond for the area and the community.

They argue that individual efforts are not enough to fight against FW. Hence, it requires involving large actors, food companies, and governments. It is invisible for people to see how much effort is put into a piece of ready food. There is a need to create awareness about the production process, which they try to change.

Lebensmittel Teilen e.V

The non-profit organisation *Lebensmittel Teilen e.V.* is active in five categories against FW: sustainable food production, food distribution, food saving, community kitchens, and nutrition education (Lebensmittel Teilen e.V., n.d.) They are promoting activities such as community gardens, permaculture and solidarity agriculture as part of their sustainable food production actions. They share the food using physical and digital platforms together. Food saving means using SF, and the companies support this by providing the food. Community kitchens are the areas where people cook and consume together, and nutrition education involves sharing and

spreading knowledge through collective activities. Their main focus area is Siegen, Germany, and they have an active Instagram page where they share their activities.

Foodsharing Cph

Located in Copenhagen, *Foodsharing Cph* was inspired by Foodsharing.de, and currently, they are one of the biggest food-sharing communities that is active with weekly activities. They have a nine-person main board that is responsible for organising the community (Food Sharing Copenhagen, n.d.). They collaborate with supermarkets and other food companies for food donations, co-operate workshops with other food clubs, and organise a variety of different activities, including “disco soup”, in which people cook and eat SF in an enjoyable way (Slow Food Foundation, 2024).

Foodsharing Luxembourg

They define food-sharing points as either a fridge or a food shelf that the public can reach. This is a volunteer-based organisation and volunteers are responsible for the conservation of foodsharing points. Currently, they have two active points of food sharing (Food Sharing Luxembourg, n.d.). They organise workshops to create awareness about food waste as well as co-operation with political initiatives.

Design Proposition for a Food-Sharing Community

Based on gathered data about organisations, we created Table 2, highlighting their working areas. The main criteria to discuss are education, community refrigerators, events and location. Food-sharing communities are based on location since people should own the community and spend time. However, for example, Foodsharing.de is spread around Germany and other big ones like Stockholm and Copenhagen also have multiple activity points. The adoption of food sharing is even more significant in bigger cities since the civilisation level and amount of FW are directly proportional (Secondi et al., 2015). Although digital interactions can support community behaviour, it is crucial to have physical interactions and feel belonging through a space. All communities have at least a *community refrigerator*, and all organise events such as community cooking and food-sharing activities. Moreover, most of the communities educate their members to strengthen bondage around food saving.

Foodsharing.de is the most complex and oldest one, so they have dozens of contacts around the food industry and food management, and they reduced FW by tons during the last ten years of work. Though cooperation between food-sharing organisations was not investigated, we believe this also could be a fantastic opportunity to share awareness. We argue that there is also a huge field to improve connections between the food market and NGOs. Unfortunately, as we discussed earlier, the policies usually do not help those in need or those who want the change. Therefore, the organisations are on their own with their volunteers, and society has a vital role in triggering the transformation, both in terms of policy and FW management.

The data in the *communication channels* column demonstrates the size and impact area of the community, see Table 2. Digital communication is crucial for these communities in terms of acting rapidly since food's life occurs and terminates in a small amount of time. *Facebook* seems to work better than *Instagram* for these organisations since it can also work like a forum, allowing others to participate in organising more efficiently.

Table 2: Comparison of Foodsharing Communities

	education	owning community refrigerators	organising events	location	Communication Channel
Foodsharing.de	+	+	+	Germany	Facebook (104k followers) Instagram (9.5k followers)
Jadłodzielnia	-	+	+	Poland	Facebook (3.4k followers)
Food Sharing As	+	+	+	Norway	Facebook (3.0k followers)
Lebensmittel Teilen e.V.	+	+	+	Germany	Instagram (1.3 k followers)
Food Sharing Cph	+	+	+	Denmark	Facebook (24k followers) Instagram (4.3k followers)
Food Sharing Luxembourg	+	+	+	Luxembo urg	Facebook (4.3k followers) Instagram (0.8k followers)

Considering the issue, we proposed a PSS design through community building that enables spreading the organisation's effect out of local context. Here, we argue that the community building principles should be enabled with the PSS design; and aligned with Octavia et al. (2022), the stakeholders are food donors, food sharing mediators and food recipients. Although Vittuari et al. (2017) involve four stakeholders, including the workers, in our PSS design proposal; we preferred to discuss the issue with three stakeholders since workers are internal stakeholders of food-sharing mediators (Figure 5).

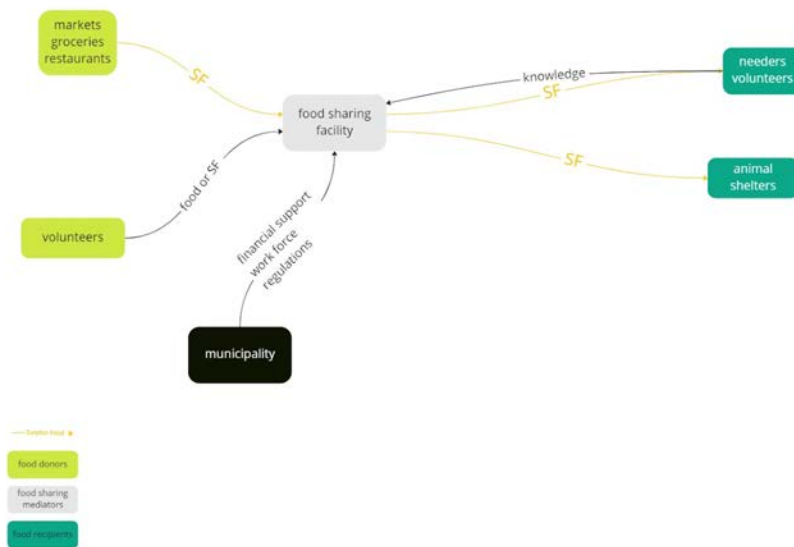


Figure 5. PSS Map Proposal

As the centre of the community, we propose a facility for food sharing that connects the stakeholders and enables them to activate against FW. Considering that food sharing is not the only approach against FW, and this facility should also create opportunities to discuss other approaches (e.g. community gardening) against FW to cause a social transformation in terms of behaviours and strategies. Markets, groceries, and restaurants are SF donors, while volunteer food donors can also provide food as well as SF. All this food is aimed to be stored in the facility for processing and consumption. Volunteers do not have to provide food; they or any stakeholder should provide activism, fairness, care, education, and knowledge exchange within the food-sharing network. Animal shelters or stray animals can gather food when there is an extra amount of SF, considering the expiration dates. Here, we see including non-human livings is as a significant issue to reduce FW in a collective manner since the SF involves a considerable amount of organic waste.

We mentioned several times the significance of physical interactions to activate SI to prevent FW, as the spatial design rules the agency in place (Dourish, 2006). Hence, we propose that the food-sharing community should own a facility, a physical space that allows activities about and around FW, such as workshops, games and meetings. Of course, the space should allow storage, preparation, and food consumption. However, not in the context of a market, store or restaurant; it should allow people to spend time within the community, even individually. The community kitchen should be an area that connects food donors, food recipients, and food-sharing mediators to share their

knowledge about how to use SF efficiently. Other than that, the discussion here should impact the FW worldwide. Hence, the community should also affect the food industry, (e.g. packaging design) education and policies through a bottom-up approach to trigger social transformation.

Aligning the Design Proposal with Sustainable Development Goals

Considering the level of complexity of emerging global issues, such as FW, designers seek solutions that enable an aimed effect on social life. Hence, as design scholars, we explored the issue of food sharing as a community-building approach. In this sense our approaches can be aligned with four Sustainable Development Goals (SDG):

- SDG 1: No Poverty
- SDG 11: Sustainable Cities and Communities
- SDG 12: Responsible Consumption and Production
- SDG 17: Partnership for Goals.

We included how SDGs are related with our design in the further paragraphs of the discussion.

Based on data collected during our research, we argue that people see food sharing as a donation at first sight. However, using SF with food sharing should be seen as saving food from the dumpster and reducing FW. Furthermore, one of the most critical issues is creating awareness through education about FW. NGOs and their educational events/campaigns should play a role here as the literature states the need for social support for the continuation of sharing (Nadeem et al., 2020) since food sharing relies on building relationships between new people (Harvey et al., 2020). Furthermore, regardless of social status and wealth, the phenomenon of using SF should be widely known; receiving SF and being a part of food-sharing systems should not be a shame, and it should not be a behaviour that poor people adopt. On the side of social benefits, it reduces FW and raise the recognition about “poverty” as our design approach is aligned with SDG 1 and 12.

The benefit of digital platforms in this digital area should be provided to communities, and we have explored many examples, this creates a potential to make a collective identity through meaningful interactions (Crivellaro et al., 2016). However, this should work in a way that supports communal life. Digital platforms should not be a mediator for feeding people but rather for gathering them against food waste since the urge to be a part of community and familiarity requires common and personal values to be combined (Bielefeld et al., 2016; Hamari et al., 2016). Hence, sharing for community model (Michellini et al., 2018) matches well with our PSS design proposal. Interestingly, this model suggests that among society, consumers and providers; consumers are the most benefitted as they get cheaper or free food as well as building networks and increasing “sense of community”, following the principles of SDG 11 and 17.

The issue of localisation and cultural background should be considered when this issue is applied since the habits and expectations slightly change among different locals, as the

sociocultural environment of food is a crucial element of food sharing (Lazell, 2016). Here, TGTG can be seen as an example; even if their strategy is not based on food sharing, it is an example that is trying to fight against FW worldwide. However, should we actually find solutions to move SF, which is the issue of logistics, or can we rather spread the food-sharing behaviour? Hence the question is: How can design enable them to expand these communities globally? Even though it can be said that the food-sharing communities can work efficiently in local areas, they should use digital channels to exchange knowledge and resources to increase their impact.

Conclusion

We covered the issue of FW and the approaches against FW, especially the ones that include SI. As an approach that has a high potential against FW, we focused on food-sharing communities. We discussed five different food-sharing communities by making comparisons between them. As a contribution to the literature, we observed this issued from the PSS design perspective, we listed possible interventions for the design of a food-sharing community. These include the design of the physical space as well as the interactions outside of the facility but builds the food sharing community. We see a potential for building food-sharing communities to change food-wasting behaviour, aiming for a social transformation that can start with local food-sharing communities by actually practising food-saving behaviours. Subsequently, acknowledging this behaviour in daily life can affect both national and international levels of awareness in terms of FW. Designers, policy-makers and practitioners can benefit from this study to intervene in the FSC to create awareness and change the food-wasting behaviour. Subsequently, aligning our design with SDGs, we believe that an incremental change can be provided by food sharing followed by education that is spread around through communities.

The main limitation of this study is the limited number of analysed food-sharing communities and their locations. Our communities were based in middle and northern Europe, even though many other local and national communities are trying to activate community building against FW. Actors, networks, and institutions form the food system's management with their own cultural, economic, social, and political characteristics (Kim, 2015). Hence, more research should be done to understand how people from diverse backgrounds can adopt food-saving behaviour through community building and how technological improvements can be adapted to include new generations.

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Design thinking for sustainable futures: opportunities to connect with other approaches

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ABSTRACT

‘Design thinking’ is often discussed in isolation, as though all that is required is to frame a problem as a design problem or approach a problem as a designer would. However, problems can be framed and approached in many different ways, such as through the application of ‘systems thinking’, ‘entrepreneurial thinking’, ‘computational thinking’ and other discipline-specific approaches. When considering the multi-dimensional challenges of sustainable futures, it is important to consider the relationships between design thinking and these other approaches, many of which are focused on developing and implementing new perspectives, options and solutions. By connecting with these other approaches, our understanding of design thinking can be enhanced through comparison, and our application of design thinking can be strengthened through combination.

Introduction

This DTRS14 symposium asks what role design could play in the shaping of sustainable futures. This issue fits well with the promotion of design thinking by development organisations (e.g. see United Nations Development Programme, 2017), and also with academic work looking at the intersection of design thinking and sustainability (e.g. see Shapira, Ketchie and Nehe, 2017; Gould *et al.*, 2019).

Although design is at the centre of this symposium’s call for papers, it is not just issues associated with design thinking that are emphasised. There are also references to how we must recognise and accept “complexity”, “a holistic perspective” and “systemic changes” (DTRS14, 2023). While complexity, holism and systemics are included in some descriptions of design thinking (e.g. Kimbell, 2011; Lewrick, Link and Leifer, 2018), these things are much more strongly associated with systems thinking (Jackson, 2003; e.g. Capra and Luisi, 2014). Just like design thinking, systems thinking has increasingly been applied to sustainability issues (Williams *et al.*, 2017), and on some accounts originates in the examination of such issues (Meadows, 2008). It would therefore seem that a symposium focussed on how design thinking can play a role in the shaping of sustainable futures would also benefit from considering the role that systems thinking might play, and how design thinking and systems thinking could play their roles together.

Of course, combining design thinking and systems thinking is not new (Jones, 2014; Litster, Hurst and Cardoso, 2022), but if we recognise that these two approaches might be useful in addressing issues of sustainable futures, then we might also ask what other

types of ‘thinking’ we should consider. Thankfully, across a broad range of disciplines, there have been efforts to characterise the ways in which practitioners from each discipline ‘think’. An obvious addition to design thinking and systems thinking is ‘entrepreneurial thinking’ (Sarasvathy, 2001; e.g. see Patel and Mehta, 2017), but there are many others, including—*but not limited to*—‘computational thinking’ (Wing, 2006; e.g. Kong, 2019), ‘engineering thinking’ (e.g. Waks *et al.*, 2011), ‘evolutionary thinking’ (e.g. Novick and Catley, 2016), ‘mathematical thinking’ (e.g. Burton, 1984), ‘geographical thinking’ (e.g. Jackson, 2006), ‘sociological thinking’ (e.g. Ruggiero, 1996) and ‘anthropological thinking’ (e.g. Tett, 2021).

If we are interested in the application of design thinking in the shaping of sustainable futures, then we might also be interested in drawing from these other discipline-specific approaches. This is because, as Boland and Collopy (2004) tell us about the introduction of design thinking into management, “[t]he more ways of thinking we have available to us, the better our problem-solving outcomes can be” (p. 11). One way to expand the ways of thinking available to us would be to survey the approaches originating outside design. We could then seek to understand how those approaches all relate to each other. The most appropriate approaches for any challenge could then be strategically identified and combined, as necessary.

Unfortunately, despite their many similarities, the projects to define and characterise different disciplinary approaches have been conducted in almost complete isolation from each other. This has resulted in descriptions that are disconnected and inconsistent, which makes it hard to identify what the different approaches are, how they are related and how they might be coordinated. To address these problems, in this short article I survey some of the many descriptions of specific disciplinary approaches, and examine the connections and contrasts between them. I do this with the hope of motivating those interested in design thinking to become additionally interested in other disciplinary approaches.

The article is structured in four main parts:

- *Part I* outlines the methodology of the work
- *Part II* summarises how disciplinary approaches are described
- *Part III* investigates how disciplinary approaches are related
- *Part IV* explores implications for design thinking practitioners.

Overall, the article is aimed at supporting those who want to research, promote, learn or apply any particular form of discipline-derived ‘thinking’ to also identify the complementary or contrasting approaches that other disciplines have to offer. In doing so, I hope that efforts to apply design thinking to challenges of economic, social and environmental sustainability can be better coordinated with similar efforts originating outside the design disciplines.

Part I. Methodology

This work takes the form of a narrative review, inspired by the principles of integrative review methodology (Cronin and George, 2020). The focus is on making connections across disciplinary boundaries, looking for areas of overlap, whether in concepts, methods or findings. Relevant review materials were primarily identified through searching publication databases for the relevant keywords and following the reference trail from one work to the next.

Although primarily a qualitative enquiry, some bibliometric analysis was used to guide the literature search. In particular, the Scopus database was searched for documents referring to different disciplinary approaches (in the title, abstract and keywords from 1954 until the search date of February 2023). Counting the results revealed the relative prominence of each approach in the scientific literature, but also the relative scarcity of works focussing on more than one of these approaches. For example, while systems thinking, design thinking and computational thinking were the three most prominent approaches (with 9226, 6791 and 4611 results, respectively), only 131 works referred to systems thinking and design thinking, and only 2 referred to all three approaches.

In addition to searching the published literature for mention of the relevant terms, some citation analysis was performed to better understand how published works from any single discipline were influencing the other disciplines. This was done by building a co-citation map of authors cited in publications referring to 'design thinking,' 'systems thinking,' and 'computational thinking.' Data from thousands of publications was manipulated to produce a co-citation map of cited authors (using VOSviewer). This confirmed that even the *most cited* works describing one disciplinary approach are seldom co-cited with (again) the *most cited* works describing other related disciplinary approaches.

In summary, both the qualitative and quantitative surveys of the literature established that each disciplinary approach is developed, discussed, researched and applied in isolation.

Part II. Descriptions of disciplinary approaches

In a popular account of design thinking, Brown (2008) contrasts the integrative and innovative role of designers with the public's perceptions of design as a merely aesthetic activity:

"Historically, design has been treated as a downstream step in the development process—the point where designers, who have played no earlier role in the substantive work of innovation, come along and put a beautiful wrapper around the idea [... but] design thinking can lead to innovation that goes beyond aesthetics" (pp. 2, 7).

Claims of this kind have often been repeated, as many efforts to describe and promote design thinking try to direct attention away from the specifics of design practice and

towards its intellectual or practical essence. In contrast, the disciplinary specifics—such as subject matter, tools and techniques—are described as a distraction that misleads people as to what really characterises or constitutes that discipline, especially the thinking involved. However, such descriptions are not unique to design and design thinking. Instead, many disciplines feel misunderstood in the way that Brown describes. This is stated particularly clearly in discussions of geographical and historical thinking, approaches that many people might imagine they already understand well enough:

“the public perception of geography is as a fact-based rather than conceptual discipline. This article is an attempt to challenge that *Trivial Pursuit* view of geography; it argues against the view that our discipline is just a gazetteer of place-names or a list of imports and exports, and makes a case for the power of thinking geographically. Geography, I argue, enables a unique way of seeing the world, of understanding complex problems and thinking about inter-connections at a variety of scales (from the global to the local).” (Jackson, 2006, p. 199)

“historical thinking, in its deepest forms, is neither a natural process nor something that springs automatically from psychological development. Its achievement, I argue, actually goes against the grain of how we ordinarily think. This is one of the reasons why it is much easier to learn names, dates, and stories than it is to change the fundamental mental structures that we use to grasp the meaning of the past.” (Wineburg, 2010, p. 84).

Similar points have been made across a wide range of projects describing disciplinary approaches. For example, systems thinking should not be mistaken for computer modelling (Meadows, 2008, p. 6), computational thinking should not be mistaken for computer programming (Wing, 2006, p. 34) and scientific thinking should not be mistaken for scientific knowledge (Gauld and Hukins, 1980, p. 109). In describing disciplinary approaches, many people have been concerned that their own disciplines have previously been confused for the specifics of the subject matter or the techniques and tools used, rather than the underlying essence of the discipline, whatever that might be.

It is a feature of many descriptions of things like design thinking and systems thinking that they are presented as being very widely applicable. These are approaches that can ostensibly be learnt by many people outside the originating discipline and implemented by them in many contexts or domains. For example, in promoting design thinking, Pressman (2018) insists that it is: “[n]ot just for architects or product developers, [but] can be applied across many disciplines to solve real world problems and reconcile dilemmas [... in] politics and society, business, health and science, law, and writing” (pp. xvii–xviii). Similarly, but now considering systems thinking, and especially the capacity to distinguish multiple system levels, Wilensky and Resnick (1999) say that the need for this “arises in many different domains, among many different types of learners” (p. 3). To give just one more example, Wing (2006) claims that, “[c]omputational thinking is a

fundamental skill for everyone, not just for computer scientists [and therefore...] we should add computational thinking to every child's analytical ability" (p. 33). So, once abstracted from their specific application domains, and framed in general terms, many forms of disciplinary thinking are celebrated for their wide-ranging applicability: if only everyone would pay attention, not get distracted by the details, and think like a designer, or a geographer, or an historian, or an entrepreneur, or a computer scientist, ...

Representations of things like design thinking are typically driven by practical goals rather than deep conceptual commitments. The challenge is capturing enough about the disciplinary approach so that it can be understood and applied by others, often influencing their own training and practice in a relatively short period. To this end, there are, just as examples, accounts of the successful application of design thinking in business contexts (Liedtka, King and Bennett, 2013), of systems thinking in healthcare development (Bashford *et al.*, 2018) and of entrepreneurial thinking in university restructuring (Jacob, Lundqvist and Hellsmark, 2003). Other disciplinary approaches are often more oriented toward educational outcomes, but there too we find reports of how training in specific disciplinary approaches positively influences outcomes in the associated disciplines and sometimes also in others. For examples, see studies of the effectiveness of training in computational thinking (Scherer, Siddiq and Sánchez Viveros, 2019), mathematical thinking (Algani and Jmal, 2020), evolutionary thinking (Novick and Catley, 2016), geographical thinking (Karkdijk, van der Schee and Admiraal, 2013) and historical thinking (Keleşzade, Güneyli and Özkul, 2018).

So, it would seem that disciplinary approaches can be learnt and applied effectively, and therefore that experts in any one approach might be able to learn and apply others. We might then ask how anyone would identify the approaches of most relevance and understand how such approaches relate to each other.

Part III. Relationships between disciplinary approaches

One thing that we might wonder about when considering different disciplinary approaches, is what each particular approach is being defined relative to. For example, are the characteristics of design thinking somehow distinctive in themselves? Or, is it that they are distinctive in comparison to the approach taken in some alternative discipline such as, say, science or art? Or, is it that they are distinctive in comparison to some 'normal' or 'conventional' way of approaching things? The same questions could be asked across the range of disciplines that have undertaken projects to define their own specific—*yet generalisable*—approaches.

Thankfully, there are some comparative descriptions available in the literature, often for two or three disciplines at a time. For example, there are well-founded comparisons between design thinking and several other disciplinary approaches, including systems thinking (e.g. Buchanan, 2019; Litster, Hurst and Cardoso, 2022; Pourdehnad, Wilson and Wexler, 2011), entrepreneurial thinking (Garbuio *et al.*, 2018; Varadarajan, 2019; Klenner, Gemser and Karpen, 2022; e.g. Christensen *et al.*, 2023) and computational

thinking (e.g. Denning, 2013; Kelly and Gero, 2021). Going beyond such pair-wise comparisons, Patel and Mehta (2017) consider frameworks of design thinking, systems thinking and entrepreneurial thinking through a detailed review of the three relevant literatures and case studies of their integrated application in practice. Very unusually, Lewrick *et al.* (2018, p. 9) actually describe such integration as characteristic of a design thinking mindset, saying that “[a]s the situation requires, we combine different approaches with design thinking, data analytics, systems thinking, and [entrepreneurial thinking]”.

That’s all focussed on design thinking, but if we consider other disciplinary approaches, then there are similarly well-founded comparisons between computational thinking and mathematical thinking (Sneider *et al.*, 2014; e.g. Rycroft-Smith and Connolly, 2019) and between computational thinking and systems thinking (Easterbrook, 2014; Shin *et al.*, 2022). Again, going beyond pair-wise comparisons, Lucas, Hanson and Claxton (2014) discuss engineering habits of mind in contrast to habits of mind in mathematics and science (with reference to similar projects in those disciplines). Similarly, Gould (2021) describes data scientific thinking as including decreasing proportions of statistical thinking, computational thinking and mathematical thinking. Even more wide-ranging is Shute *et al.*’s (2017) discussion of computational thinking in comparison to mathematical thinking, engineering thinking, design thinking and systems thinking (again with reference to projects in those disciplines).

Some authors have clearly recognised that the forms of disciplinary thinking that they are interested in (whether that is just one or a few) can be related to others. However, note that although these various works compare different disciplinary approaches, they typically describe whatever disciplines they are engaging with as though they are a naturally occurring set, or the only set available. For example, Kelly and Gero (2021) describe design thinking and computational thinking as “the only two forms of thinking to gain prominence since the turn of the 21st century” (p. 2), and Shin *et al.* (2022) say that to “fully explain complex phenomena or solve problems using models requires both systems thinking (ST) and computational thinking (CT)” (p. 933). There are seemingly very few examples where disciplinary approaches are described not as a small, bounded set, but as a general class that is (or can be) populated with contributions from almost any discipline. Perhaps the clearest example is found in the Epilogue of Denning and Tedre’s (2019) book on computational thinking, where they point out that

“everyone thinks their own field’s ways of thinking (and practicing) are valuable and worthy of learning in many other fields. Enthusiasts want to spread the gospel of success to other fields. The list of ‘thinkings’ to be spread is long: computational thinking, logical thinking, economic thinking, systems thinking, physics thinking, mathematical thinking, engineering thinking, design thinking, [...] and more” (p. 213).

Part IV: Implications for design thinking practitioners

As we have seen, many of the motivations for describing and promoting design thinking overlap with the motivations that other disciplines have offered for describing their own ways of thinking. There is the suggestion that each discipline has developed effective ways of looking at, engaging in and changing the world, and that such ways can be applied to contexts beyond those that each discipline is traditionally associated with. Despite such similarities, it is quite rare to see descriptions of design thinking that connect with more than one or two other approaches (most often just with systems thinking or entrepreneurial thinking). However, when we consider the many varying and complex contexts to which design thinking is applied, then we should recognise that a broad range of disciplinary approaches might be required, and that these might need to be navigated between, combined and integrated. This is clearly the case when considering sustainable futures, where relevant perspectives and actions might come from economics, sociology, engineering, politics, legal practice and many other disciplines. The question is how the approaches that are most central to these different disciplines relate to design thinking, and how such relationships might best be understood and responded to.

Aside from scholarly or professional interests, there are at least three practical tasks that design thinking practitioners might undertake that would benefit from being expert in the relationships between design thinking and other disciplinary approaches:

1. When researching design thinking, it can be valuable to understand the research that has already been conducted on other approaches that design thinking is connected to and those it is distinct from. For example, some research on entrepreneurial thinking has employed quite different research methods (despite the similar subject matter), and research on scientific thinking has a very long history to draw from (even if the subject matter is quite dissimilar).
2. When designing educational interventions intended to promote design thinking, it can be valuable to draw from the educational interventions that other disciplines have already developed for their own disciplinary approaches. For example, work on computational thinking has focussed on how specific principles from that disciplinary approach can be embedded in curricula across a broad range of subjects.
3. When forming diverse teams to identify, frame or address problems (e.g. in co-design), it can be helpful to ensure that teams are composed not only of demographic or functional diversity, but also a diversity of disciplinary approaches. For example, while designers and entrepreneurs might bring an inclination to prototype and iterate, ecologists might focus on adaptation over time, computer scientists might focus on abstraction and economists might focus on opportunity costs.

These three tasks point to the need for a map that visualises how design thinking relates to many other disciplinary approaches. To encourage the production of such maps, I'll

sketch out a possible starting point here. To represent design thinking, I'll take Micheli *et al.*'s (2019) description, with its ten components. It is then possible to search the literature for other disciplinary approaches that connect to each of these components. For example, Micheli *et al.*'s second component—'user-centredness and involvement'—is often taken to be a hallmark of design thinking, and similar components can be found in other descriptions of design thinking, such as those offered by Kimbell (2011) and Lewrick *et al.* (2018). However, the empathy and self-reflection required for user engagement and co-design, might also be characteristic of anthropological thinking, while the approaches of other social sciences (such as geography) have components that connect to this too. Such relationships are sketched out in Figures 1 and 2, not just for Micheli *et al.*'s component of 'user-centredness and involvement', but for all ten of their components, each mapped to the components of specific descriptions of other disciplinary approaches.

A map like that sketched in Figures 1 and 2 could form the basis for exploring other disciplinary approaches. This need not be limited to just eight approaches, but could include many more, including approaches related to sub-disciplines (e.g. 'service design thinking', 'human geography thinking') and inter-disciplines (e.g. 'systemic design thinking', 'synthetic biological thinking'). Such a map would be useful in supporting the three tasks outlined above, those relating to design thinking training and also to practice. This is because it would allow the identification of related approaches or just related components of approaches, providing a basis for communicating across disciplines, drawing on those disciplines and coordinating people from those disciplines.

Of course, Micheli *et al.*'s description of design thinking is just one of many, and so also are the descriptions of each of the other disciplinary approaches in Figures 1 and 2. If we instead focussed on different descriptions of design thinking and other descriptions of the other disciplinary approaches, then we would arrive at a different map of their relations. However, although such a map might be different in its details, it would not necessarily be fundamentally different. Different descriptions of a single disciplinary approach (such as design thinking) might differ in the specific components they refer to and the way in which those components are labelled and defined, but when those components are regarded as a set, then the way they characterise the discipline is often fairly consistent.

Even considering the above points, some important questions remain:

1. How should we identify the most relevant disciplines to draw approaches from?
2. How should we identify or produce the most suitable descriptions of each approach?
3. How should we represent the relationships between approaches to allow people to find, compare and combine them?

Perhaps the DTRS14 symposium will be a productive venue to explore these questions, especially considering the specific context of sustainable futures.

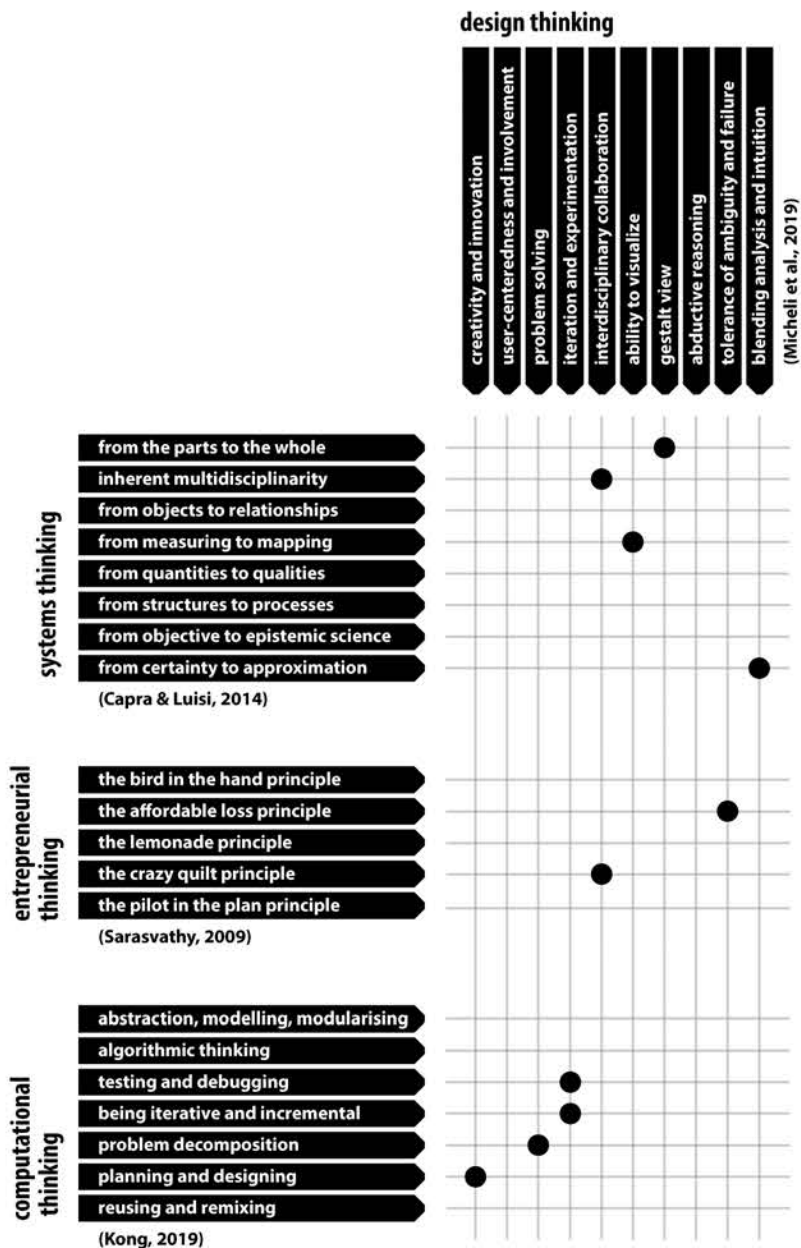


Figure 1: Illustration of how a description of design thinking can be related to descriptions of systems thinking, entrepreneurial thinking and computational thinking.

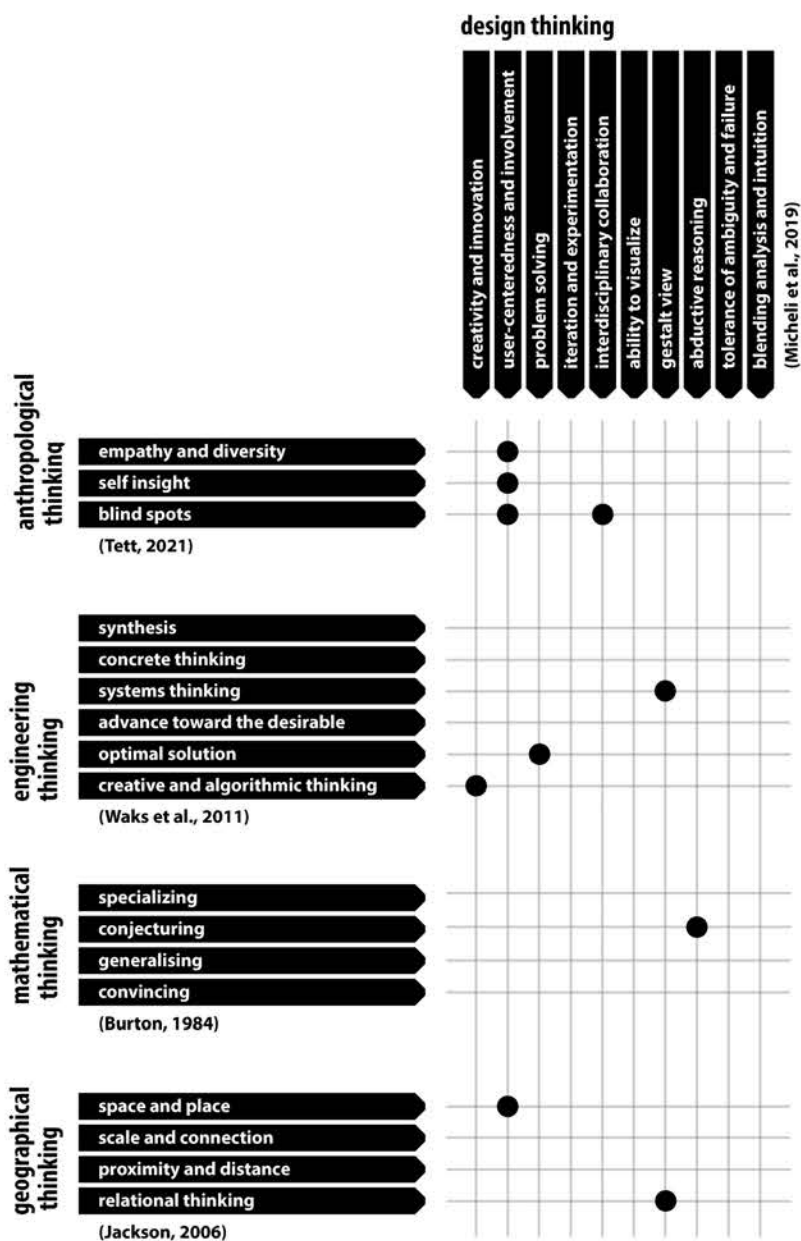


Figure 2: Illustration of how a description of design thinking can be related to descriptions of anthropological thinking, engineering thinking, mathematical thinking and geographical thinking.

Conclusions

This paper began by considering questions about the role of design in sustainable futures, but also the recognition that this would involve addressing issues of complexity, holism and systemics. While this kind of discourse naturally leads to the consideration of how design thinking and systems thinking can work together, this paper has reported on and sought to motivate a wider search for other related approaches that might also have a role to play. For example, discussions of design thinking often emphasise empathy for users and other stakeholders, but so too does anthropological thinking, historical thinking and economic thinking. Another aspect of design thinking that is often emphasised is change-orientation, but this is also a hallmark of engineering thinking and entrepreneurial thinking. Turning to systems thinking, there are many variants of this, but also other related approaches, such as ecological thinking and evolutionary thinking, each of which emphasise different perspectives on holism and change. In summary, the disciplinary approaches available to us are many and varied, and we should not be restricted in those that we research, teach, promote and apply. Sustainable futures might benefit from the application of design thinking, but might also benefit from other approaches that design thinking can be combined with or contrasted with. Identifying, relating and mapping these approaches would be a first step toward supporting people in recognising the approaches that are available and selecting those that are most suitable for their purposes.

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Designing for hypercomplexity: a case study

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ABSTRACT

The shaping of transitions is the great challenge of our time – in the coming years all of the ‘systems’ in our societies (energy, care, transport, education, etc) will have to change, fundamentally. And they will have to do so simultaneously, creating hypercomplex problem situations. In this paper we will explore the challenge of dealing with hypercomplex problem situations by proposing a design-driven approach. This will be illustrated through the case study of the Nitrogen Crisis in the Netherlands: through the design and implementation of a learning approach, the whole system is moved to a more dynamic state. This movement is then supported by a design-based ‘Studio’ infrastructure, creating a mechanism for ongoing change.

Keywords: Complexity, Transition, Design Practice, Studio.

Introduction

When challenge of addressing multiple transitions in-parallel (Loorbach, 2010), we enter the era of hypercomplexity (Dorst, 2025). In dealing with hypercomplex problem situations we will have to find a response to their (1) layeredness, (2) lack of systemic connections and (3) the weakness of their causality.

- (1) - A hypercomplex problem situation sits across several systems and is fundamentally layered. The UN Sustainable Development Goals are a good example of such a layered and connected problem arena: see Figure 1 (and Section 1 of this paper)



Figure 1: The Stockholm Resilience Centre 'wedding cake' model of the UN Sustainable Development Goals)

- (2) - Often, systems change proves to be difficult because there IS no overall 'system', in the sense of a clear and coherent arena for intervention. That will need to be created before progress can even be made (Schaminée, 2018, 2023) (Section 2 of this paper).
- (3) - In hypercomplex problem situations, the idea of direct causality is lost. Direct causality is based on a direct relationship between cause and effect (if X then Y) – but in this brave new world, when we do 'X', there will be many effects 'Y' that we cannot foresee – this requires us to move away from 'problem-solving' thinking, towards a fundamentally different, much more experimental design-based approach (see Section 3).

In this paper we will explore what design can offer to address these three challenges of hypercomplex problem situations. This will be done through one extensive case study, concentrating on the Nitrogen Crisis in the Netherlands (based on (Schaminée et al, 2021)).

1 The Nitrogen crisis: paradoxes, complexity and layeredness

In the late 2010s, the Dutch government was involved in a court case about Nitrogen Pollution. The Netherlands is a signatory to the Paris Climate Agreement, and the lawyers from an activist NGO took the state to court over failing to protect designated nature reserves (designated as such under the EU Natura 2000 rules) from Nitrogen pollution. Nitrogen oxide emissions mostly come from transport, building works and agriculture (about 45%). The problem is that Nitrogen acts as a powerful fertiliser, dramatically altering the soil, and thereby also the flora and fauna in these nature reserves – which, the lawyers argued, is not allowed. In the end, the protracted legal process came before the country's High Court, and in March 2019 the court ruled in favour of the NGO, rendering the government in breach of the law.

This ruling came into force immediately, and had huge repercussions all through society:

- (1) to reduce the emissions from transport, the Dutch government reduced the maximum speed on the highways from 130 to 100 km/h.
- (2) About 18,000 ongoing building works (that happened to be close to the nature reserves) were ruled in breach of regulations, and all of their earlier permissions were voided. They had to be stopped, immediately.
- (3) The ruling impacted agriculture more than any other sector: many farms would now have to radically change their practices to cut their Nitrogen emissions. Farmers were up in arms, and marched to The Hague to protest in front of the Dutch parliament – and they came on thousands of tractors, effectively blocking traffic in the whole country for days, week after week (Tullis, 2023).

The Dutch ministry that was at the centre of this crisis, the Department of Agriculture, Nature and Food Safety (LNV), enlisted André Schaminée and his team from the consultancy TwynstraGudde to look into this matter. Their approach to both

understanding the problem situation and creating proposals for ways forward was largely design-based, using a Frame Creation process (Dorst, 2015)(Schaminée 2018).

They started out by doing about 60 interviews with various stakeholders from across the problem arena. This led to the identification of 4 main paradoxes: (1) It is a zero-sum game, (2) It is not clear who we are listening to (3) The farmers are the victim of government policy failures (4) the value-models and value discussion are not sufficient. (There were more paradoxes, but these four cover the problem arena well enough for the purposes of this paper). To elaborate:

1 - It is a zero-sum game

When the discussion is stuck in an either-or-pattern (a piece of land is either for 'nature' or for 'agriculture'), there is only conflict, and no room for dialogue. This is exacerbated by the fact that Nature and Agriculture both have value and meaning, but that these are of a very different kind. For instance, one of the solutions that could result in short-term improvement of the situation would be to reduce livestock by buying out 'peak emitters', farms that are positioned very close to nature areas. But that calls into question the deep values underlying the very successful intense farming paradigm that has been stimulated in The Netherlands since the second world war. And on the level of the lifeworld of the farmer, this would probably be the end of a family tradition of generations (in a densely populated country, the chance of relocating is very small). Another possible solution lies in transitioning to a new type of nature-inclusive agriculture. But this will be a much slower way to reduce nitrogen emissions. In the lifeworld of the farmer, this is not a small step either, adopting such a different paradigm requires new practices and also a reconsidering of values (what it is to be a 'good' farmer). In a way, it is easier for both parties to stick to their existing value sets and not budge.

2 - It is not clear who we are listening to

There is a suggestion that the farmers are united, as they have organised themselves in cooperatives. But it is not clear whether these cooperatives have the same interests as the individual farmers. Some of these organisations represent 'the farmer' in government committees. But do they represent 'the farmer' – it is clear that there is tension there: their standpoints are not always consistent across these discussions. At the moment, this leads to extreme standpoints and political posturing by these associations to reassure their members that they are fighting the good fight. Yet the crisis at hand will only be resolved when all parties are ready to offer considerable compromises. This is not going to be easy – the farmers movement is supported by the big companies that have a vested interests in the continuation of the current system.

3 - The farmers are the victim of government policy failures

While the farmers blame 'the Greens' for the Nitrogen crisis (despite the Green Party never having been in government), the more farmer-friendly political parties whose policies over the years have actually led to this crisis are not widely questioned. While

the sector complains about 'going from crisis to crisis', there is very little appetite to look forward, to the next problem that are going to come to the agricultural sector (drought, water management, Nitrate pollution). Some parties – like feedstock companies, and to a degree also the supermarkets - have a vested interest in the current situation, and see no incentive for change. These same parties also act as consultants to the farmers, and the narratives they push are reinforced by the professional media in the agricultural sector. Farmers that could be willing to reduce their livestock feel they are not heard – and based on earlier experience, they feel uncertain and threatened by the inconsistent nature of government policies over the years. Trust in government is low, across the sector.

4 - The value-models and value discussion are not sufficient

While a change in agricultural practices is proposed as the only viable option, there is no clear path of action for the farmer – what would a new business model look like? Economically, this could only work if there is a structurally higher price level for nature-friendly produced foods, and that consumers are willing to pay this. This doesn't even limit itself to The Netherlands: while the Nitrogen problem is framed as a Dutch issue, but food prices are often determined in European and global markets. Because there is no economic value to nature, the only thing that gets counted in economic terms is 'a loss of value to farming'.

These four paradoxes on the relationship between Nature and Agriculture have been exacerbated by the lack of connection between the layers of the problem area (spanning the world of policy, the systems world, the lifeworld of citizens and the biosphere – see Fig. 2).



Figure 2: Layers of hypercomplexity

These layers all have their own scale, dynamics, timelines, history and way of addressing the future. They all have their own vicious cycles and learning cycles. But they are mostly disconnected, as 'worlds to themselves'. For example: the timeline for substantially changing the Biosphere (have plants change the soil, preparing for the natural

succession of other plants) takes about 50-70 years. In the Life World of the farmers, generations are important (handing over the farm to the next generation) hence the timeline is 20-30 years. In the world of systems and organisations, the horizon is often not more than 2-5 years, often substantially less. And in the world of Policy, there have been continuous changes as the government is struggling to influence the sector. This disconnect between timelines plays out in real life, in many different ways. For example, one of the farmers interviewed had invested heavily in a technical fix: 'air cleaners' that filter the nitrogen oxide from the air that gets emitted from the stables. The hefty investment meant he needed new bank loans, which can basically only be serviced by increasing the number of livestock. But then, in 2027 new regulation will come into force to improve the surface water quality in the country – this will most likely mean that livestock will need to be kept away from the waterside (by about 3 meters). This can only be achieved by keeping less livestock... We can theorise about paradoxes and the nature of first order and second order effects, but what we are looking at here in the lifeworld of this farmer is financial ruin.

Society in general doesn't seem to know or understand the situation – which is difficult, as the general societal discussion is the place where a (re)balancing of values needs to be reached in the end. And in this discussion, nobody represents the future: from a larger and longer term perspective, farming is also adversely affected by a crisis in the realm of nature (the changes in biodiversity, the depletion of the soil, etc...)

2 The Nitrogen crisis: towards a learning system

Nowadays, there is a lot of talk about 'systems change' as the great challenge of our times. Yet in this case, this is hard because there effectively IS no system – a system consists by virtue of its connections, and is held together by feedback loops, that are lacking here. There are lots of parties in this problem field, with a wide variety of interests and drivers, each doing what they see as best, or just furthering their own interest. For 'systems change' to occur, a system needs to be made first, relationships and feedback loops need to be installed. Because of the nature of this crisis, the team of TwynstraGudde set out to design and develop needs a compelling new set of frames to define these relationships.

To link the learning cycles on the four layers and address the vicious cycles that were expressed in the paradoxes, we need

- (1) a common value discussion (see paradox 4)
- (2) we need frames that go across the levels, to spark common learning cycles
- (3) the development of a new professionalism by all involved.

To get beyond the first paradox, we need to create a way forward in which the agricultural transition can contribute to vitality in nature AND to vitality in farming (as a practice, and as an enterprise). There is no blueprint for this, and no clear way to achieve these goals. We really don't know. That is why we need to design and develop a learning

cycle in which vitality in nature is going to be part of the vitality of the agricultural system – and vice versa. Such a learning process should do justice to the many aspects of the complex transition, the many interdependencies (second-order, third-order effects) that will determine its dynamics (pushing it away from a linear change process based on direct causality). This means that we need to create a structure for an ongoing change process, rather than a single activity (a ‘project’). There is no simple ‘silver bullet’ solution – striving for that is fruitless, and will actually distract us from the work that really needs to be done. In this program, the team structured its activities in a learning cycle (see Fig. 3) that is designed around two axes: thinking vs doing and professional vs societal conversations.

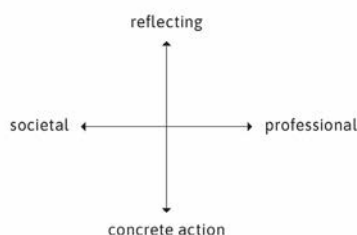


Figure 3: The axes of the learning cycle

Along the learning cycle the designers developed six distinct activities that need to be realised in the program (Fig. 4).

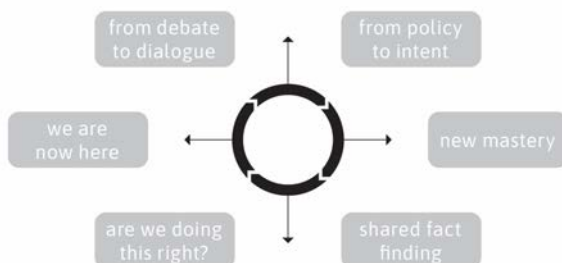


Figure 4: Activities along the learning cycle

They have been conceived these to address the exact spots where a more linear process would have stalled: in the current situation, policy doesn't correspond to its intent, the stakeholders can just further their own interests because they are isolated from one another, there is no consensus on the facts (with the farmers organisations calling into

question the NO_x measurements), there is unclarity on the (long term) effects of policy changes and society at large is not involved in resolving what is really a societal problem.

The invitation for stakeholders to join this experimental journey is based in the shared themes that emerged in the frame creation sessions, that concentrated around notions of Mastery (= relationship with the world), Identity (= relationship with self and your peers) and Vitality (= relationship with the future). These framed new ways to approach the problem area. They are not separate projects or experiments: they are positioned these along the learning cycle to create powerful ways forward.

How could this work? Lets take an example and follow through the scenario that then unfolds.

Understanding starts with the other: we have to realise that the protection of nature can be a threat for local farmers. That is, if we keep thinking in terms of a zero-sum game, where more nature equals less agriculture (the very concept of 'nature reserve' reinforces this thinking). But protecting nature could also be an opportunity – could we conceive of a way to create 'nature value' as well as be productive in growing food? The challenge then becomes to co-create this new type of stewardship, in a way that includes farmers, naturalists, policy makers and indeed society at large. This requires a joint definition of the new practices and 'new mastery' needed to collaborate across these domains – all the way from agreeing on a way to measure the results in the field to creating new business models for farmers, and checking whether the policy is capable of creating the space needed for experiments that create the new practices needed to realise the original intent. Sharing experiences and insights will lead to better questions, that spark new experiments... etcetera.

This initiative is called 'Fields of Freedom', and put it in the middle of the learning cycle of Figure 4. The idea behind 'Fields of Freedom' is to create an experimental space where potentially disturbing variables are 'muted': that could be the regulatory framework, or the market forces of 'return on investment'... once the experiment is underway and new possibilities emerge these variables will be brought back into the discussion. The key is that there is an unconditional trust in the craftsmanship and mastery of the participants.

What does this look like? The idea of the 'Fields of Freedom' originates when the partners (from agriculture and nature conservation) are selected and make a first rough plan/approach. From the 'designer-as-a-conductor' role, the learning cycle is then mapped to create an overview of the way this initiative touches the other frames. What kind of knowledge and skills (*New Mastery*) are we going to need? How are we going to measure the effects, what will be the sensors in the field to give us the shared basic data? (*Shared fact finding*). How are we going to articulate the various kinds of value that are going to be created here? (*How are we doing?*), and which stories are woven together here? How do we attract other people to caring about the Field? (*You are now here*). How are we going to discuss the value that could be created, and with whom? (from *Debate to Dialogue*). The value discussion will lead to new questions, for which we will need to create new 'Fields of Freedom'...

3 Learning from the masters: meta-design

This kind of development requires structural support, a common innovation infrastructure. Four different types of activity need to be organised in concert: Experimenting (reframing and acting) , Learning (draw lessons from these experiments, and also spread these lessons to create new mastery), Communicating (invite comments/feedback from within the sector and broader society, to feed a public discussion) and Growing (this is about organisational, professional and personal change)

To get at sense of how this might be shaped, we can look at the way design professionals have organised these practices. After all, design studios are structured to support creation, exploration and change, on a continuous basis - in contrast with the 'classic' organizational model of the industrial firm, which is organized around exploitation [Smulders, 2006].

Leading architects, designers and artists take great care to develop the intellectual (and physical) environment in which the design activities of their agencies takes place. These environments embody the culture of the company, and nourish the inspiration and reflection that enables the particular kind of projects that the firm excels in. In the following quote, famed Singaporean architect Ken Yeang is reflecting on his office (from [Lawson et al., 2013]):

"Any architect with a mind of his own, whether by design or default will produce an architecture which is identifiable to that architect...I had to study ecology, I had to study biology; that was the basis for most of my design work. I'm trying to develop a new form of architecture. We have this climatically responsive tropical skyscraper agenda and each project we try to see whether we can push an idea a little bit further... I give every new member of staff the practice manual to read when they join. They can see not just past designs but study the principles upon which they are based. We work these out over time, over many projects...."

The agenda of the firm is very clear, and there is a set of very deliberate activities and working methods which support that agenda, creating a balance between continuity and change within the design practice.

"I do competitions more as an academic exercise. I treat competitions as research projects....it motivates the office - gets them excited - lets the mind develop new thoughts and themes. I put all the drawings together and publish a book... look in this book, these were our competition drawings for Kuala Lumpur and people said 'how can you spend so much time doing drawings and so on' and I say 'it's research, it develops ideas.'"

The projects and other activities like competitions, exhibitions, presentations and publications are seen as part of a very explicit strategy for developing the practice into the future. Ken Yeang and other outstanding architects influence what happens in their office by overseeing the building and continuous development of the approaches to problem situations, strategies, particular knowledge, special skills and a range of possible solutions that are all part of the common heritage. It captures the experience of

the firm as it develops (resulting in the 'common stories' and an overall narrative). Yet these firms only survive in a dynamic environment when they are dynamic constructions, when they are able to go through great changes over time.

Likewise, Jerry Hirshberg [1998] describes how the Californian branch of Nissan Design was deliberately shaped by him to prioritize creativity, rather than a smooth and efficient 'production' process. Taking *'The Creative Priority'* seriously requires a complete rethink of what an organization is and does. His principles include: (1) ensure creative abrasion by creating polarity in projects (2) hire people in divergent pairs (3) use tension as a springboard to create new insights (4) always stress creative questions before creative answers (5) regularly step back from the canvas and reflect (6) stimulate failure and play (and cheating - fostering a culture of forgiveness and humor) (7) blurring the disciplinary boundaries and foster intercultural creativity (8) don't just focus on the 'core business', do other things as well to diversify sources of inspiration (9) trust intuition, make the space and take time to build it up (Hirshberg talks about 'informed intuition'), (10) porous planning, to cater for open learning processes. From a creative practice perspective, all of these principles make sense - this is what it takes. Hirshberg holds up a mirror to organizations who say they want to be innovative, yet try to achieve that within conventional organizational structures and linear processes that are not fit for purpose.

In his book *'The Transdisciplinary Studio'*, Alex Coles [2012] takes an anthropological approach to describe the complex and multifaceted practices of four leading artists/designers in greater detail. Through multiple interviews with various staff members he seeks deep insight into the high-level practices that keep such a Studio both coherent and fluid. For the purposes of this book, we will concentrate on Studio Olafur Eliasson as an example:

"Architecturally, Eliasson's Berlin studio is structured precisely so as to enable and promote this transdisciplinary model. On the top floor resides a school from which a Master of Fine Arts course that he leads is run, on the ground floor the work is fabricated, while the middle floors are divided between an office with architects, designers and model makers, and a space where his room-sized installations can be tested. The overall ambience of the studio is of a densely constructed think-tank in which artists, designers, architects, theorists and scientists collaborate to fashion new experiences and dialogues in the form of exhibitions, seminars and publications - all under the banner of Studio Eliasson."

In addition to this studio in Berlin, Olafur Eliasson also has a small studio in Copenhagen that is not focused on project delivery but serves as a reflective space, and a campervan on Iceland for landscape photography. All of these elements are inextricably linked in his oeuvre [Eliasson, 2023].

What Yeang, Hirshberg and Eliasson are pointing towards are higher level creative practices. They transcend the projects that design is normally associated with, presenting a 'meta' level of practices for creating the infrastructure, the context for the

practices and projects that sit within the ‘philosophy’ of the firm – as well as the continued intellectual development across the projects.

4 The Studio model

We have seen in the case study that this is exactly what is needed in the context of the Nitrogen crisis: we need to create an ongoing change process around the relationship between Nature and Agriculture.

The four ‘types of activity’ (experimenting, learning, communication and growing) that are needed to drive Transitions can be organised into the four ‘spaces’, of a design-based ‘Studio’ model (Dorst, 2025) that stand in a dynamic relationship with one another: the Lab, the Academy, the Podium and the Temple (Bouwknicht, 2023). Sustaining these activities in these four spaces is a prerequisite for the type of continuous change we associate with system vitality.

The Lab is the infrastructure for reframing and experimenting. In terms the Game Changers model (Dorst et al., 2023) it strategically initiates the bottom-up experiments that creates new practices within the organisation, as well as feed into the development of a new Field – so the top-down processes are synchronized with the bottom-up ones. This is crucial: a system only really shifts when in shifts on every level. The Lab is both the place of inspiration and exploration, as well as the locus of the confrontation of ideas and dreams with reality.

The Academy is the infrastructure for learning within and outside the organisation, as well as across the wider innovation ecosystem. This is crucial, because in true systems change it is not just organisations that will need to shift their practices, but whole professional fields that will need to reconsider what they do, and what is quality. For example, whatever the precise outcome of the experiments and debates, it will in the future mean something else to be a farmer (away from maximizing production towards more sustainable types of farming). This means that the education of farmers will also have to shift. Failing to do so would mean that through conventional schooling, we would continue to ‘copy’ the old way of working into the new desired system. But building a new curriculum is a notoriously slow process, so the educational institutions of the key professions involved in the system will have to be closely involved in the experiments as they happen, picking up the new practices as they emerge.

The Podium is the infrastructure that makes sure we change in constant open dialogue with the relevant context. Failing to do so could easily lead to new unquestioned assumptions creeping into the new practices, making them less than realistic and in the end creating risk (assumptions are the major cause of risk and failure). Experience has shown that it is good to set a strict rhythm for the Podium activities: in creating a rhythm, the Studio people are continuously challenged (‘What are we going to show?’...‘What are we going to do?’...‘Who should be there?’...). This creates a continuous strategic discussion on what matters, and on the nature of the quality the Studio is

developing. The Podium is a dynamic self portrait, open and extended out to the public, and deliberate in making the newly emerging practices vulnerable.

The Temple is the infrastructure for (personal and organisational) growth, anchoring the deep change and the new paradigms into the core of the organisation and its people. The Temple is a reflective, contemplative space but it is also one of reckoning, making the change real on a personal level. This includes critical reflection on a personal level – does the direction the organisation is heading make you feel alive? (This is the *'Quality Without a Name'*, see (Alexander, 1979)).

Each of these four infrastructure 'spaces' of the Studio is important – it is only when all are present and dynamically interrelated that there is systems vitality. The separate elements of the Studio can be recognized in current activities and theories ('learning organisation', 'thinktanks', 'skunkworks', etc) but for Design Abduction to happen (Dorst, 2015), these elements need to be present – all of them, and all the time. That requires an effort and a commitment from organisations in creating these spaces, and holding on to them lightly so the activities remain fluid. There is only so much that can be organised around the studio, in this creative space informal relationships are crucial as they are driven by inspiration and growth (Bjorklund, 2015). The Studio is not an 'innovation department' but a network of people that come together as needed. It should involve people from across the organization (and beyond); innovation is a relay race that involves all departments of the organisation in the process of shepharding an initiative from inception towards realisation and impact (Dorst et al., 2024).

5 Conclusion

It is clear that the hypercomplexity of the Nitrogen crisis pushes us beyond the realm of 'normal' problem solving and 'normal' design projects.

Creating a new approach to deal with hypercomplexity is only becoming more pressing as the world is moving into a decade of major transitions. But these often get misdiagnosed as complicated or complex problems (Snowden, 2007). This is probably because transitions don't really show themselves as such. The Department of Agriculture, Nature and Food Safety didn't commission the Twynstra Gudde social designers to work on a transition. Climate change and the need to adapt our agricultural practices to stay within environmental boundaries are an underlying factor. But the Nitrogen crisis very much did show itself, in a way that could not be ignored. And much to their credit the people in the department realized that this was not a one-off problem that needed to be fixed with a one-off solution. This was just one crisis, symptomatic of an intense industrial-style agricultural system that had been under stress before (BSE, swine flu, avian flu) and needed to learn how to deal with many other crises to come (drought, salination of the ground water, the need to deal with increased risk of flooding from the rivers). A transition is needed to create a relationship between nature and agriculture that is strong enough to respond to the crises of the future. It was clear from the start that nothing would move unless there was a path to new business models for

farmers as they transition to more sustainable agriculture. The studio model is an open structure to support this learning.

The good news is that in being painfully realistic about the hypercomplexity of the problem arena, that same complexity gives a basis for new patterns to emerge.

The Nitrogen example shows that in the case of transitions, a design-based Studio itself is the key outcome of the whole program. It can be harnessed to not just approach the current immediate crisis (Nitrogen) but empowers us to take charge of future challenges.

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Future Hunter: framing social change in times of transition

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ABSTRACT

The shaping of transitions is the great challenge of our time. For our institutions and enterprises to respond properly to this challenge, they will have to change: their business as usual approaches were never made for this level of deep and comprehensive systems change. This brings up many pressing questions. What does a transition challenge actually look like? What is an appropriate approach? What can we expect as an outcome? What is a 'good' transition? In this autoethnographic paper we will show an example of a pioneering design-driven approach to transitions led by business and community leaders in the Hunter (Australia). In presenting this case study, we will describe some core aspects of a design-based methodology to shape this process.

Keywords: Transitions, Social Design, Reframing, Design practices.

Introduction and research context

One thing we know for sure, is that we are going to go through enormous transitions in the coming years: urgent change is required. Overwhelming changes are coming to the way we deal with resources like energy and water, and how we approach care, mobility, education and prosperity. Each of these transitions is monumental in itself – and they are going to happen simultaneously, in parallel. While these transitions are often phrased as economic challenges (transitioning to a new industrial basis), they also hold a huge societal challenge: if we fail to create these transitions in an integrated and inclusive manner it will always be the same people that are going to be left behind, potentially creating a new and very deep rift in society.

Designers have been engaging with social issues for more than twenty-years, under the flag of 'social design' or 'design for society' (see for instance Tromp & Hekkert, 2020). Originally these design contributions were focused on a project level, with localised interventions, but gradually social design has been taking on bigger 'system level' challenges - focusing on redesigning the way whole organisations and/or sectors operate (for instance: 'Redesigning Psychiatry' (Holierhoek, 2020) and Designing for the common good (Dorst et al., 2016)). Transitions are yet another higher level of complexity, requiring us to engage and operate across sectors to help reshape the way societies will operate in the future.

We cannot assume that the paradigm (in the sense of Kuhn, 1969) of design practice - traditionally coming from a 'project' level - will seamlessly operate and lead to results and impact on the level of societal transitions. Mainstream-design takes place in the context of the relationship between the designer and the commissioning party (Paton & Dorst, 2011), while in transitions the problem ownership is often distributed. The realisation that design has something to offer in this space has led to initiatives like the Design Impact Transition platform at Erasmus University Rotterdam (DIT, 2023, Loorbach et al., 2024), the Transition Design groups at Carnegie Mellon University (Irwin, 2022) and University of Technology Sydney (Tonkinwise, 2015). These are experimental units in which the knowledge, theories, methods and practices of (social) design and transition management are brought together. From a design practice perspective, this is interesting because from this combination, a new type (or subspecies) of design discipline might emerge.

In this emergence, there is a steady stream of case studies and reflective papers coming from these pioneers. These descriptive case studies are often implicitly autoethnographic, and sometimes explicitly (see Bailey, 2021). They contribute to a more comprehensive picture of what a new design practice or design discipline could look like - when enough time has passed, with enough snapshots to see a bigger picture. Then design research can be important in consolidating this knowledge from practice and create a way forward (See Dorst & Watson 2023). In design research, theory often follows the development of design practice in this way: empirical research into what is happening in design practice leads to a deeper understanding, connecting the new practice into the body of knowledge (to other models) and bringing in theories scaffold reflection that helps elucidate the new practice for education and training purposes.

But sometimes this role of research-following-practice is *reversed* and theory is needed upfront, in an active role, to help create new design practices (and perhaps a new discipline) that the professional field in its normal evolution, probably wouldn't get to. This puts design research into a different, leading role.

To illustrate this point (of innovative design spawned by theory and research), we can look to the advent of Interaction Design in the late 1980s - early 1990s. At that time computers were moving closer to consumers, helped by a new generation of graphic interfaces. The internet was possible, and one could think about it, but it was as yet unformed. These exciting developments were spawning a new breed of specialist 'Interface Designers', growing out of the graphic design discipline. This early work in interface design tended to be functionally orientated, geared towards supporting fairly simple and direct on-screen interactions ('buttons on screens'). Visionary thinkers/designers Bill Verplank and Bill Moggridge, working from Xerox PARC and IDEO, realised that this was not going to be enough in the future - the complex interactions *themselves* needed to be designed, before the interfaces could be created to support that interaction. This is a huge conceptual leap, putting the interaction centre-stage as a *new object of design*. How was this going to work? How does one design something as invisible as an interaction? What knowledge needs to be drawn together to

do this well? What is Quality in interaction? How can this be taught? One of the first places where the challenge of creating a curriculum for Interaction Design was picked was at the Utrecht School of the Arts in The Netherlands in a close collaboration with Centre for Knowledge Technology at Utrecht University. Designers, researchers in cognitive artificial intelligence, methodologists, artists, futurologists, and visionaries came together in a conceptually strong team under the leadership of Dick Rijken [Barfield et al., 1994] and basically spawned a new design discipline [Dorst, 2025].

While much of design research is analytical and reductive, at the moment that existing design practices need to be extended and new ones formed, design research becomes experimental and propositional. This paper marks such a moment: we have used theories on complexity, transdisciplinarity and transition management to explore what is needed to create a type of (social) design that is suited to deal with societal transitions. These practices, based on theories and models, are applied as experiments in pioneering case study projects that can then be observed and analysed through empirical research. Hence this is a descriptive paper, using the Hunter case study to explore the fledgling new practice as it is seeking to achieve the intended outcome and impact. This work is also exploratory in that it creates new questions and challenges to the design field; for practice, research and education. In pushing this boundary, we offer our initial experiences up for reflection and discussion at the DTRS14 conference.

It is important to mention that in the context of the central (Hunter) case study, and the autoethnographic methodology behind the paper, the authors of this paper are all "insiders" (Mosse, 2006) to various extents. Each with different levels of involvement in the Hunter case study: The first-author (Kees Dorst) draws on his experience as an active insider in the Eindhoven case and has led the thinking behind the design-led approach to the Hunter transition. The second author (Rodger Watson) played an active first-hand role in the Hunter case, facilitating elements of the stakeholder workshops, and engaging research partners. The third-author (Simon Byrnes) has the deepest first-hand insider perspective from his former position as Chief Commercial Officer at the Port of Newcastle, and working with the other authors whilst undertaking his Masters at UTS (2020-2024). The Hunter transitions were the key focus of Simon Byrnes' studies.

1 Transition

To formulate a more inclusive and sustainable response to transition, we draw on transition thinking and lessons from social design. In this paper, the authors will use these lenses to inform and reflect on a real-life case study: the upcoming transformation of the City of Newcastle and the Hunter Valley region.

Transitions are so big that they tend to be hidden – they are background processes to the crises and changes we can observe in the everyday. But we can study transitions that have happened after the fact. These can be analysed and understood, drawing lessons for the future. Two quick examples can illustrate the complexity of the transition challenges and highlight some of the lessons that can be learned from the pioneers.

The case of Eindhoven: a city reinvents itself

For an example of a spectacular (but partial) success, let's consider the transition that the city and region of Eindhoven, in the Netherlands, has experienced in the last 20 years. In the early 2000s, the giant consumer electronics firm Philips saw its markets shift to the point where it realized it was no longer fit for purpose. After a decade of 're-organisations' to keep the boat afloat, the firm decided to create spin-offs of its most successful new ventures, sell off its consumer electronics branches and completely concentrate on the professional market in the medical domain. The industrial city of Eindhoven, which had literally grown up around the Philips factories and their need for workers, shifted very quickly into an open innovation model (Horsten, 2016). The now abandoned factories were turned into creative hubs, high-tech firms were drawn by the well-educated workforce and twenty years on the city is thriving like never before (see 'Brainport' and 'High Tech Campus'). However, this great success also holds a cautionary tale: the industrial shift to a 'deeptech innovation ecosystem' has come with the creation many new high-tech (engineering) jobs. In the Netherlands, the rules and regulations in the educational system inhibit the University from scaling up quickly to meet this demand, so expats are coming to region in their thousands, pricing the local people out of the housing market. This situation is expected to worsen dramatically as the authorities expect another 70,000 high-tech vacancies over the next 10 years (Romme, 2022). In Eindhoven, there are now voices for more democratic control over this development.

The lesson to be learned here is that great economic success comes with great social upheaval – and that in terms of transitions: in the end, if it doesn't work for society, it doesn't work at all.

The case of Chemelot: from coal to oil-based chemicals to...

Something similar is now underway at the oil-based chemical factory near Sittard, in the south of the Netherlands. When the coal mines closed in the early 1970s, the Dutch State Mines reinvented itself as a chemical/materials industry, based on oil. Now that oil-based products are declining and eventually coming to an end, shifting to bio-based chemistry is no mean task. The old mine-site-turned-chemical-factory has been renamed (see 'Chemelot' and 'Brightlands'). It has opened its gates to startups and experimental labs to use the facilities and to benefit from the chemical/process know-how and the high safety standards. The area now employs 8,500 people in 75 industrial companies and in 80 materials development companies – and most importantly for the future - there are 1,200 students there now, on a continuous basis. It is also one of the anchor points for a broader regional transformation, the surrounding countryside is now part of an IBA (see 'Internationale Bau Ausstellung' and 'IBA Parkstad').

Like Philips, the Chemical industry complex is using an open innovation approach to engage in what is basically an act of creative self-destruction. This involves stepping back from the form things have taken, historically, and to concentrating on content – a process of deconstructing, reinventing and rebuilding differently. This is all built on a broad consensus, in industry and in society, that 'we can't go on like this'. What these

transitions also show is that real systems change is a huge responsibility to take on, too much to bear for any one party (often leaving them without a clear 'problem owner', because they are everybody's problem they are nobody's problem). The precise consequences of a structural transition are hard to predict – this holds true if we consider each of them separately, but especially when they coincide, when transitions come together influencing the lived world of the citizen (a 'perfect storm').

Conventionally, technological and economic development thinking would lead these kind of change processes, and people's lives and society would be left to deal with the dire consequences (Bourdieu, et al., 1999). This will not do. The challenges before us are so radical, systemic and deep that these four developments (technological, economic, societal and individual) need to be considered in parallel - and societal transformation should inform and guide the technical and economic change, rather than the other way around. More than ever, this makes transition and change a *design* question. Before going on to considering design practices that might help creating a path forward, we will now turn to the field of transition management to explore the repertoire of practices that were created there as an inspiration for designing, developing and leading transitions.

2 Understanding Transitions – what makes this hard?

Transition scholars ask the question why transitions don't just happen, when the need is by now abundantly clear. Why do institutions and organisations full of clever professionals not just move with the times? What makes this hard? What structures and practices get in the way?

The challenge of Regime change

Loorbach (2010) poses that the current way of working, or 'Regime' has an inherent coherence and stability as it combines *cultural* aspects (images/values/paradigm), *structures* (institutional/economical /physical) and *practices* (routine/rules/behaviour) in an integrated whole. And it undoubtedly has been successful in doing so, for many years.

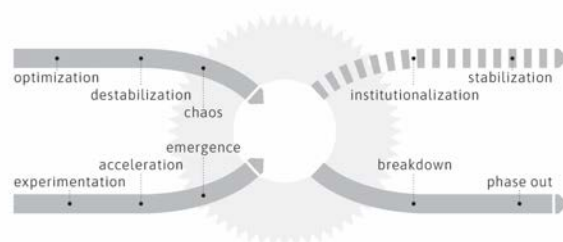


Figure 1: The X-curve model of transitions, as used by DRIFT

This Regime – much like Kuhn's (1969) 'dominant paradigm' in the times of 'normal science' - seeks to optimize its current modus operandi. But as the X-curve model (see figure 1) posits, changes in the environment will start to destabilise this equilibrium. In such times, experiments with new ways of working also emerge. First these pioneers will be attracting 'early adopters' as backers, later they might grow to challenge the incumbents. In figure 1 we see that at a threshold moment, the current regime will start to unravel and move to being phased out. A new regime will take over, and start its own process of institutionalization and stabilizing, becoming the old regime of the future.

The challenge of disciplinary stability

Within organisations, professionals use practices that are part of their disciplines - what Kuhn (1969) earlier termed: their 'disciplinary matrix'. These disciplines have arisen and developed within a certain era and environment, and hence they come with their own (historical) baggage (what Foucault (1972) terms, "cultural residue"). This includes assumptions that tend to become implicit, and therefore harder and harder to question over time - especially when questioning them would also mean questioning the definition of Quality that is implied in a disciplinary matrix. Then people can feel attacked and become very defensive ('am I not doing my work right?') and defend their current practice 'to the death' (Watson & Dorst, 2022). Because disciplinary change is often a gradual process that is almost imperceptible on a daily basis, disciplines can create a false sense of stability and security, which is a blocker to change.

The challenge of capability

The points above address different ways in which the will to change can be limited – organisations and systems disciplines are built for stability. But what if there is a will to change, but there is a lack in capability to change? Transition science lists four ways in which we can lead ourselves astray, and our organisations lack the capability for real change (after (Loorbach, 2010), (Schaminee, 2018) and (Braams, 2022)):

The implementation-illusion – this means we rationally discuss the issues and make plans, in the illusion that somebody will actually do this... and nothing happens, while the discussion is stuck in abstractions and analysis.

The responsibility gap - risk aversion leads to a modus operandi in which only small steps are possible. The responsibility is spread very thinly in the organization, so nobody is centrally responsible for the big ambition. Luyendijk (2015), in his anthropological description of the Banking sector after the 2008 financial crisis called this 'the empty cockpit'.

The innovation funnel – always focusing on creating something new, often with technology, while being blind to the new things that are already happening. And blind to the fact that in creating the new practices, there is a disturbance of the status quo (what will have to be stopped?).

A lack of imagination – people are not always able to imagine that things will be different in the future. The fallback assumption is that tomorrow is much like today, and any change will be gradual. Research has shown that because most of the day-to-day changes we are dealing with are linear in nature, people have difficulty in picturing exponential growth and sudden 'threshold moment' shifts in circumstances.

The challenge of misdiagnosis

Another way in which organisations might get off on a wrong footing is through misdiagnosis of a problem situation – underestimating what is at play and starting out with the wrong methods and practices. There is a fundamental difference between the practices, methods and tools needed for optimisation, transformation and transitions. For example (Schaminee, 2023): the change to electric cars is an *optimisation* (making an existing car "better"). A move to self-driving vehicles revolutionizes their use, and the role of transport in our lives, as we can then do all sorts of activities while in transit. This is a *transformation* (making transport "different"). But then, this leads to be a true *transition* when it radically changes the way we conceive of what a city is, of how and where we can live when transport becomes completely fluent (there is no reason for self-driving cars to park close to your house or destination, or be owned by an individual - 'revolutionizing' not only transport, but also many other domains of life).

The challenge of ownership

The flipside of the great possibilities that come with such a transition is a lack of ownership: there is no single stakeholder that is dominant in such a complex problem space (in the above example: 'who owns a city?'). Transitions are, by definition, 'nobody's problem'. Therefore, transitions easily fall between the cracks of our organisations, and are not furthered because there is no clear line of responsibility (see above).

3 Designing and developing Transitions

Transition challenges tend to reach beyond the levels of the project and organizational change, to the paradigms that underlie sectors and disciplines, where they touch bigger questions of societal transformation.

Reflecting on the above, one cannot but conclude that each of these barriers to transitions is formidable... and they are often combined in complex problem situations. It becomes so hard to make change that the result is no action. In a very real sense, we don't yet know how to do this – this is a design challenge in itself. Transitions are *open, complex, dynamic and networked* problem situations, and we will see in the next section that there are design practices suited for addressing these (Dorst, 2015, 2025). But first, we need take some time to understand the nature of these problems. Point by point:

Open

In an open problem situation, it is very unclear who the stakeholders are and what their roles are going to be. This is where the transition management's modeling transitions in

terms of 'old system' and 'new system', gets in the way – the question of who creates a new system is wide open. In creating fundamental change, the content (value and meaning) should lead, and the new (organisational) form in the end follow. The who, what and how are all to be (re)designed – as is the case in Open Innovation (Chesbrough, 2003).

Complex

Complexity is an important determinant of this process. The many parties involved, their relationships and interdependencies thwart any attempt at linear problem solving. Really complex problem situations don't require endless analysis, in such a situation we need to experiment and learn. The good news is that when we do this, and accept the complexity, we will see which new patterns emerge. The goal is not to 'solve' the problematic situation (in complex situations, 'solutions' don't exist) but to create interventions that make the whole system move to a better state. We have seen this strategy at work in the cases in section 1: in Eindhoven, the 'Brainport' organisation designed an infrastructure to support open innovation, and the new economic base of the city then shaped itself. This does require a 'design conductor' to put stimulus where is needed, and good, consistent support for initiatives that are strategically important in this respect.

Dynamic

What needs to be supported is a learning cycle. In a parallel paper, we have introduced the design-based Studio model (Dorst & Schaminee, 2024) as a way for organising experimentation (the Lab), learning (the Academy), reflection (the Podium) and growth (the Temple). We will see the Studio model in action in the Hunter case study that follows in the next section.

Networked

In regional transitions, this innovation ecosystem should reach right across society, creating a 'societal midfield' between the domains of the Government, Public Sector, Private Enterprise and the Citizen (see figure 2 – please note that this is also where organisations like Brainport (Eindhoven) and Brightlands (Chemelot) sit). Strategic projects that connect the people, thinking and actions ('practices') of these four domains lead to the deep insights needed to create more open, dynamic and networked 'new world' practices to tackle the really big societal challenges.

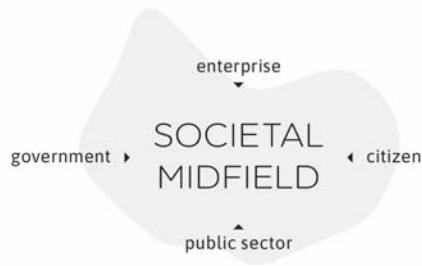


Figure 2: The Societal Midfield

In the end, all-of-society challenges require an all-of-society approach to designing all-of-society societal answers.

4 Future Hunter case study

The Port of Newcastle, in the Hunter region just north of Sydney, is the largest coal port in the world, and proudly positions itself as “Australia’s deepwater global gateway”. Like many other ports and regions, it will need to shift away from a coal-based industry and infrastructure to finding a role in a world that moves towards renewable energy. The port has set up a program “diversifying for the future and investing to support thriving communities, local jobs and a prosperous Hunter region”. Its centrepiece is the development of a 220 hectares Clean Energy Precinct on remediated land. The precinct is powered by a green energy infrastructure (one of Australia’s biggest ‘Green Energy Zones’ is projected in the hinterland), the port has excellent facilities (excellency in supply chain management), and is supported by a strong alliance of local stakeholders. The broad alliance of project partners include clean energy producers, electricity infrastructure companies, stakeholders in the gas network/power generation, heavy industry, traditional port activities like logistics, export and bunkering, as well a mobility and infrastructure providers, the university and other local educational institutions.

The technical, industrial and economic questions that are facing this innovation ecosystem of companies and institutions are formidable: what for instance, should be the role of Hydrogen with Ammonia be in this new economy? It could be a useful carrier of energy for the local industry, but exporting ‘raw’ energy in the form of liquid hydrogen is a relatively low value-add proposition. Greater value could be created by new industries that capture the energy through added value in goods – or even in raw materials like steel and aluminium. But greater added value is created in new biochemical industries, for instance through the use of algae to create complex carbohydrates. But that would require an investment in new technology development, developing whole new industries, as well as investment in new infrastructure.

What type of industry could thrive if green energy was available in abundance? What type of industry could support a regional economy that is strong, sustainable and inclusive? What type of industry could be supported by the local educational institutions, so the good people from Newcastle and the Hunter Valley can thrive in the new economy? Just asking this last question immediately gets us into the realm of social design transitions. Who are the current people in Newcastle and the Hunter? Who will be the future people that the region will attract through its shift in activities? What do they want and need? And this also raises red flag: education is notoriously slow to shift, so one would need to start the educational change now, or risk leaving people behind.

To complicate matters, the city of Newcastle and the Hunter Valley are of course dynamic already, evolving in many ways (1) socially, we see a generational shift, with younger generations having completely different levels of education, jobs and needs than their parents. (2) There are many new people coming into the area. During the Covid lockdowns, and changing work practices (working from home) people from nearby Sydney discovered the beauty and lifestyle of Newcastle and the Hunter, and have flooded in. (3) This in turn has made housing much more expensive, making it harder for local young people to live in Newcastle. The challenge for this transition to create a strong, inclusive and sustainable economy and society for the region, in itself, is a break with the past. Historically, a lot of the wealth generated in Newcastle and the Hunter was flowing to business owners in Sydney and elsewhere. Value was always extracted from the region, the challenge going forward is to reverse this and actually use design as a way to create value that benefits the region.

So the central questions for the Hunter are: How to transition? Transition towards what? What is a good idea? And by the way, what *is* 'good', in a transition, when everything is shifting?

These are too many questions, so many unknowns - this is not 'a problem' that needs to be 'solved', this is a development that needs to be designed and given shape over 20 years or more. The Port of Newcastle and the partners in the Hunter Innovation Network are taking on this challenge, under the working title 'Taking charge of future challenges'.

The strategy in the first phase of this development is to start with an open mindset (minimize assumptions) and focus on designing desirable futures, not on the inevitable counterforces. The key value to strive for is to create Vitality in society. (Please note: 'Resilience' is not a valid goal here – that is the capacity for a system to bounce back from disturbance, while what we are seeking here is systems change, 'Vitality' is a very different concept). This requires a broad involvement of many stakeholders across the city and the region.

Before we can even begin to move forward, we have a first challenge to tackle: when we want to achieve 'systems change' we assume that there *is* a system to start with – while this is not often the case (Dorst, 2025). After all, a system only hangs together when there are relationships and feedback loops. But the city of Newcastle and the Hunter

Valley together make up a huge area, that has many communities, many industries, and many ways of looking at the world.

If we want people to be involved in the discussions and help the balancing of values in this development, they should first develop the capacity to contribute. People contribute to these discussions from their lifeworld, but when the ask is way beyond their social space they tend to fall back to their small world and self-interest. In the IBA regional development program mentioned in the Chemelot example, this was addressed by designing a multimedia environment ('IBA scoop') that helped in bringing the whole area together in people's experience, in people's view. An immersive environment is needed to give people a sense, a feeling of the whole.

The next phase will then be to create design-based Studios in the various domains, to support their reframing. These Studios go across the various stakeholder groups: they involve not only the companies and other usual institutional suspects (as one would do in open innovation), but they should include a good cross-section of the societal midfield. These Studios then are linked, coming together in a regional innovation ecosystem, creating an infrastructure for open social innovation.

Experience has shown that sometimes these design-based Studios might turn into (social) enterprises in their own right, but that is not a goal in itself. It is the discussion itself, and the social space to have these discussions that are most important.



Figure 2: Impression from the initial taking charge of future challenges workshop – by Nina Pirola, graphic scribe.

The reframing work in these studios is then based on a keen understanding of the culture of the city and region as it is realised in objects, customs, stories, rituals. The culture shows what values and meaning are important, now and in the future, and inspires to find (where needed) leverage points for the reframing and creation of new forms. In this case, there is a strong can-do attitude; massive change has been part of the

culture before and there is a pride in having the grit shown to deal with that. But the flipside of this is that the region has in a sense become good at enduring change that was brought upon it by outside (economic) forces. The challenge going forward will be to design and shape its own future. Keeping the grit, and finding new grist. Similarly, there are elements of the economic makeup that the region will have to move away from: the extraction-based economy and the low added value, also very much part of the culture, do not hold vitality for the future. The pressure is on to design valuable and meaningful alternative pathways that are more attractive for the current and future communities. Future strengths can be quite different – e.g. knowing how to create a wholesome transition in ports is a valuable 'export product' in itself. Newcastle can be a frontrunner in a development that many ports, internationally, will have to find a shape for in the coming decade.

Much can also be learned from the examples in section 1: in uncertain times, open innovation is at least a good start. This requires an infrastructure to support startups and other initiatives, a sustained financial investment climate. And as this is a bottom-up process, it naturally needs to involve the community. The Port and all partners involved are aware of their responsibility and duty of care in designing and shaping this long-term development - and that these great opportunities can only materialise when they involve and benefit the community in a meaningful way.

5 Conclusion: creating space for deep change

To develop vitality in the region, we first need to design this space for deep change.

In the above case study, this is approached through the principles of Open Innovation, and the creation of learning cycles. Crucial infrastructure to support these learning cycles are design-based Studios (Dorst & Schaminee, 2024) where new frames are created, leading to on-the-ground experiments and the development of new narratives. The case study shows how industries, cities and regions can come together to rethink and (re)design societal developments – creating an integrated view of a future worth wanting, and building the infrastructure to get there.

The creation of such a Studio environment is a design in itself. This is not designing 'a solution' as a response to a set 'design problem' in a predetermined brief. The object of design here has shifted to creating the infrastructure for imagination, experimentation, learning and change. Transitions are not singular changes: they require many initiatives, and a strong support infrastructure to get around the many obstacles. The appropriate response to the overwhelming complexity of transitions is not to create a recipe of method, but to concentrate on designing and building the infrastructure to navigate this complex and changing landscape.

This is a good moment to think back to the 'Interface Design' versus 'Interaction Design' example: would this type of 'social design infrastructure' *as an object of design* similarly require the creation of a new (social) design discipline?

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Layer-by-layer Design.

Design Inference in Additive Manufacturing for circularity.

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ABSTRACT

The contribution explores the intersection of Additive Manufacturing processes and Circular Economy principles, aiming to leverage design interventions for sustainable socio-technical changes. It employs the Issue-Concept-Form model to qualitatively analyze five case studies and their AM adoption implications on various scales, including social, cultural, ecological, and technological aspects. Findings focused on environmental impact assessments, systemic-thinking mindsets, stakeholder involvement in design processes and standardization of circular materials for sustainable AM strategies, contribute to informing intentional design practices for circular systems. Despite examining a limited number of cases to test the method for meta-knowledge extrapolation, a starting point for expanding specific research areas, such as investigating certain levels more in-depth is provided, paving the way for further exploration and development in sustainable design practices.

Keywords: Additive Manufacturing design, Design for sustainable additive manufacturing, design inference, circular design, circularity

Introduction

Rapid technological advancements and societal' behavioural trends fueled by consumption-driven economies have led to the overexploitation of planetary resources, marking the era that began in 1950 as the Anthropocene (Vezzoli & Manzini, 2007; Tonkinwise, 2014). This resource depletion is evident in indicators like 'Earth Overshoot Day' and 'Domestic Material Consumption Rate' (DMCR) (OECD, 2024). In recognizing the need for change, Europe advocates for a shift towards a Circular Economy (CE) model (United Nations, 2015; Delbeke & Vis, 2019; CE, 2020), aiming to eliminate waste, circulate products and materials efficiently, and regenerate natural systems by design (Ellen Macarthur Foundation, 2013). In CE circularity is achieved by closing the loop in both material and energy flows, emphasizing renewable and low-carbon alternatives, reducing virgin material demand, and revaluing waste through industrial symbiosis (McDonough & Braungart, 2002; Pellizzari & Genovesi, 2017; Cléries et al., 2020). CE limits the throughput flow to a level that nature can tolerate and utilizes ecosystem cycles in economic cycles by respecting their natural reproduction rates (Korhonen et al., 2018).

In this context, Advanced Additive Manufacturing (AM) processes emerge as a technological solution contributing to energy and resource efficiency (Fidan et al., 2024).

AM introduces new possibilities and meanings (Rognoli et al., 2015; Carullo et al., 2017; Langella, 2019; Sörensen & Thyni, 2020), presenting multi-scale challenges and opportunities for circular materials to lower environmental impacts. This study explores AM processes' benefits and circular design considerations. Design's role as an interference variable is highlighted through case studies across different scales, showcasing the AM's transformative potential in promoting sustainable paradigm shifts and outlining challenges and opportunities in integrating circular principles. The study delves into practical experiences to bridge theoretical assumptions with real-world applications. The insights gained aim to inform and guide intentional design practices for circular systems using AM technology, potentially facilitating paradigm changes across various innovation scales. This contribution represents part of the author's doctoral research, focused on circular materials (Pellizzari & Genovesi, 2017), emphasizing the crucial role of design in facilitating the transition towards CE models.

Additive Manufacturing: benefits and constraints for CE model

Additive Manufacturing (AM), also known as "rapid prototyping," revolutionizes digital technology by enabling the creation of intricate geometric shapes directly from Computer-Aided Design (CAD) models. In contrast to traditional industrial machinery, and depending on the design complexity, AM saves time and resources in limited productions (Stavropoulos, 2023). AM's layer-by-layer deposition minimizes material and energy usage compared to traditional subtractive processes, offering advantages in sustainability – such as clean manufacturing, quality control, and supply chain simplification, etc. (Hegab et al., 2023) – aligning with the Sustainable Development Goals (United Nations, 2015) by promoting economic, social, and environmental efficiency. Nevertheless, AM barriers include time and cost savings as the primary drivers for adoption, particularly concerning overall design complexity (Stavropoulos, 2023). High production costs may arise due to slow layer-by-layer deposition in complex designs (Lunetto et al., 2021; Hegab et al., 2023). Additionally, more AM constraints reside in limited production size and low-quality surfaces necessitating post-production treatments for quality alignment. While AM processes utilize various resources (ceramics, metals, plastoics), challenges persist in material availability and high costs related to powder atomization processes (Kassym & Perveen, 2020), hindering sustainable applications and technology scalability. Ongoing research explores recycled materials for matrices, binders, and reinforcement to enhance its sustainability (Tu et al., 2023) while standardizing new raw materials for the AM sector is recommended for further exploration (Hegab et al., 2023).

The author refers to the Design inferences in AM to its drawing solution based on AM settings and constraints such as topology optimization. This inference heavily relies on the designer's understanding of algorithmic constraints (Stavropoulos, 2023). Early design stages significantly influence the production life cycle, shaping its environmental implications (Papanek, 2022; Kupfer et al., 2022). Initially focused on experimental uses, AM has evolved expanding its applications and improving efficiency and materials.

Today, it holds promise for circular economy strategies by enabling distributed and local manufacturing (Kupfer et al., 2022). Compared to traditional processes, AM allows the design of complex components, resulting in lightweight, jointless structures with on-demand and customized production. This reduces virgin material input (over 90%) and waste, and lowers energy consumption (Hegab et al., 2023). The ecological implications of AM include enhanced resource efficiency, waste reduction, lower material consumption, lower energy usage, and on-demand customization. Life Cycle Assessment (LCA) is commonly employed to evaluate these ecological aspects, providing insights into AM production sustainability. However, LCAs often overlook the life cycle's holistic evaluation, neglecting the influence of consumer habits and behaviours on production impacts (Paris et al., 2016).

Circularity in/and/for the Additive Manufacturing

Incorporating circular strategies of resource efficiency into AM can capture added value and orient new business models (Hegab et al., 2023). Designing circularity in AM requires a holistic paradigm shift through short, medium, and long strategies, involving various sectors and stakeholders (Virtanen et al., 2017; Reikea et al., 2018). Different circularity models have been developed, including the iconic 3Rs principles (reduce, reuse, recycle) and Cramer's more comprehensive '10Rs' framework (2017) but not all of them could be included into AM processes. Despite circular models can engage creators, users, designers, producers, retailers, and consumers at different system levels throughout the product life cycle(s) (Reike et al., 2018), these principles often involve a cascading approach common in industrial production (Ramakrishna et al., 2019). While AM can integrate less environmentally impactful materials compared to traditional production, the engagement in circular practices often leads to a moderate decrease in fundamental technical properties during the material flow's cascading process (Timm et al., 2023) unsuitable for AM quality requirement. This poses challenges for the end-of-life transition of AM products into secondary raw materials with viable business models (Hermann et al., 2018), requiring careful evaluation of waste streams before recovery in the AM sector (Hegab et al., 2023). This may increase significantly time and cost factors.

Design sustainability for the Additive Manufacturing

Sustainable development requires transformative interventions at technological, social, and political levels (Pereno & Barbero, 2020). Design for Sustainability (DfS) approaches have emerged to address these challenges, shifting the focus from technical aspects to a human-centred, holistic perspective (Ceschin & Gaziulusoy, 2016). Ceschin and Gaziulusoy (2016) classified DfS approaches into four innovation levels spanning at micro, meso, macro, and meta scales, with the latter involving radical interwoven changes aimed at transitioning towards new socio-technical systems. Design's contribution to sustainability and CE models is well-discussed, emphasizing technical design practices from materials and products to business models and industrial systems (Ceschin & Gaziulusoy, 2016). AM stands out as an enabling technology for designers to

address multi-scale complexities and maximize product performance (Rosen, 2007; Tu et al., 2023). While AM is prevalent in sectors like biomedical engineering, aerospace, automotive, and food (Hegab et al., 2023), it opens new design spaces in other sectors (Romani et al., 2021; Tu et al., 2023). Design for AM (DfAM) has evolved, shifting focus from characteristics to function-based design (Stavropoulos, 2023). Romani and colleagues (2021) highlight DfAM's attention to larger-scale projects, particularly in engineering field. Designers exploring the values of secondary raw resources emphasize the potential contribution of circular materials for AM sustainability through experimentation and co-design projects (Romani et al., 2021). However, niche opportunities for design contribution across AM applicative sectors needs to be further inquired – with social and environmental implications often overlooked in traditional ecological assessments (Paris et al., 2016) – as design has transformative potential, realigning values, ethics, and meanings in technical, social, and environmental systems (Earley, 2017). This research contribution aims to respond to the following question: What are the design interference variables in AM technology at multiple scales that can influence material circularity valorization? In doing so, the contribution delves into the analysis of design variables of inference in AM in real-case contexts to facilitate the exploration of broader applications and the scale-up of scientific discoveries.

Method

The theoretical foundations discussed earlier have been analyzed from a practical perspective to identify potential connections for Design agency. A case-based reasoning method, as proposed by Zambelli (2022), stimulates experiences-based reflection for addressing current issues. It has been conducted a qualitative analysis focused on identifying design driven-inferences across the different scales – addressing evolving concerns of stakeholders from businesses to governments and systems (Ceschin & Gaziulusoy, 2016; Papanek, 2022) – delving deeper into the material realm, scaling the analysis to the material, micro, meso, macro, and meta (5M) levels (Fig. 1). The 5Ms levels were designed by the Design for Sustainability Evolutionary (DfSE) Framework (Ceschin & Gaziulusoy, 2016) and serves as the classification basis for case studies. Classifying, interpreting, and deducing design variables of inference from case studies phenomena lead to mitigative design solutions across multiple innovation scales, serving as potential drivers for sustainable-thinking paradigm changes. Building blocks of meta-knowledge and adaptive guidelines are derived for each level by extrapolating valuable concepts from concrete examples.

The Issue-Concept-Form (ICF) model

The method allows to deduct relevant meta-wisdom that could facilitate designers in holistic and sustainable thinking while working with AM within the CE context. The

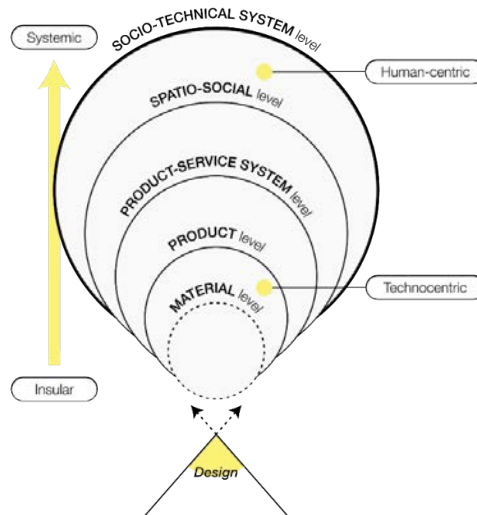


Figure 1: The methodological approach of the 5M scales: Material, Micro, Meso, Macro and Meta.

Issue-Concept-Form (ICF) model, adapted by Oxman (1994) for architectural purposes and refined by Zambelli (2022) to embrace the design practice, allows for breaking down, interpreting, and deducing learnings from case studies. The model allows deconstructing a case study in conceptual keywords or labels regarding questions or goals of the projects (issues), potential design solutions to solve issues (concept) and physical features to materialize concepts (form). As a result, a semantic map is designed displaying inter-correlations between meta-knowledge blocks. Furthermore, open ends network of keywords can be read in any directions and amplified by adding more cases and involving different perspectives. Each reading direction highlight potential alternatives to the same concerns, revealing commonality between different scales of projects and enhancing changes in various realms. The case studies investigated are:

- Material level: the Planter project by Ious Studio
- Micro level: the Poko Lamp by vanPlestik and Lisa Vlamings
- Meso level: the MX3D bridge by MX3D start-up & partners
- Macro level: the The Zero Waste Lab project
- Meta level: the Erosion Mitigative Units (EMU) by Alex Goad and the Reef Design Lab

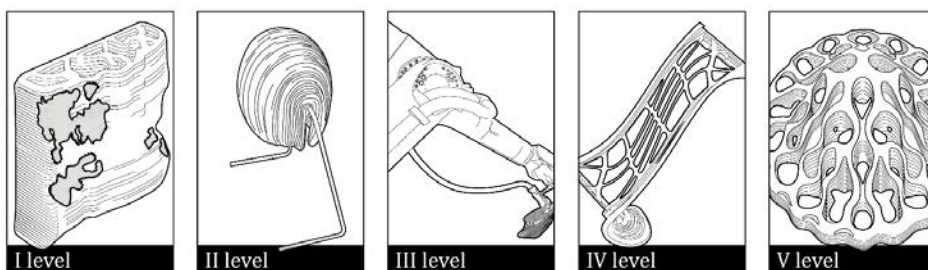


Figure 2 – Representation of case studies involving AM technologies classified by the author through 5M levels.

Cases (Fig. 2) were selected for their relevance in contemporary design and engineering realms – Some have received Sustainable and Design awards, while others were chosen for their innovative features and were exhibited at international Design fairs – responding to the descriptions of the various 5Ms levels. They were also selected based on the availability of information, gathered from online material databases, relevant documents on companies, and specialized sites such as Dezeen.com, Isola.Design, and Materialdistrict.com. The analysis criteria include a comprehensive approach involving AM process, incorporating Circular Economy 10Rs strategies, considering secondary raw materials and adherence to circular strategies, and a focusing on recent projects to ensure relevance and innovation from 2018 to the present.

Results

To illustrate the relationship between the key concepts outlined in the ICF model across the 5M levels, a visual network diagram has been designed. This representation, as shown in Fig. 3, underscores the intricate connections and potential pathways of design inference.

Intertwines

By tracing the progression of ICF variables from higher-order to lower levels, the diagram displays how these elements interconnect, fostering a more holistic and systemic approach to design thinking. Each level showcases how the identified variables contribute to the advancement and application of sustainable and circular design within the realm of AM. Moreover, it demonstrates how these elements mutually influence and contextualize one another within the broader landscape of design, promoting a cyclical exchange of ideas and insights. The interconnectedness depicted in the diagram underscores the necessity of adopting a multidimensional and integrated perspective to tackle challenges and foster innovation across various scales within the design process.

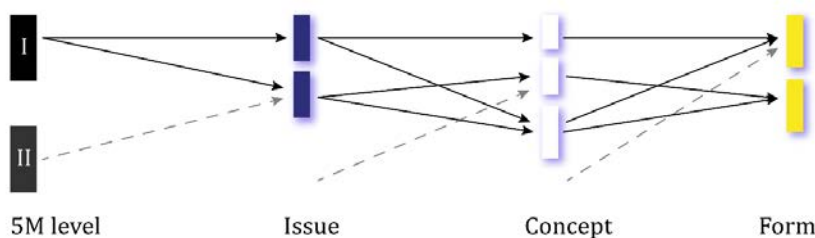


Figure 3 - The Issues-Concept-Form models connection across the 5M scales.

Material Level

The I level (Fig.4) provides an overview of disruptive experimentation that delves into the design realm of *animate materials* (The Royal Society, 2021) artificially created to imitate the properties of living biological systems. By introducing the concept of 4D

printing, the design process comes up beside the material agency, thus the material become programmable, adaptive, and sensitive to the surrounding environment (Emidi, 2023). In that case, the Designer could intervene directly in the matter, instructing it (as if it were a device) to execute commands such as "replicate," "grow," and "repair" (Oxman, 2014; Rognoli et al., 2015; Yu et al., 2020). Nevertheless, literature displays that a product or a material can also be designed to *be lived* by living beings, exhibiting new attitudes (Guillitte, 1995; Pollini et al., 2022). Integrating Computational and Bioreceptive Design (Pollini et al., 2022) can support the generation of new connections between biology and design. By shaping and layering with AM technology and designing materials to host living organisms such as lichens, fungi and bacteria, the final artefact can be enhanced, acquiring the capability to react and respond to environmental conditions (Pollini et al., 2022). Materials challenge designers to become alchemists (De Giorgi et al., 2020) experimenting with cross-fertilization between constructed, cultivated, and augmented matter (Oxman, 2013) with constructive design techniques malleable, interactive, and thriving organic systems such as the Planter project by Ious Studio. The layer-by-layer design enhances the bio-receptivity of the clay, fostering the development of performative architectures (IOUS Studio, nd.). The encapsulation of the moss in its 3D-printed layers of clay extends the product's capability to serve as a pollution filter for air, sounds and water, eliminating toxins, ambient noise, and nano-plastics.

Micro Level

The II level (Fig.4) pertains to the effectiveness of the design process in enhancing existing products or creating new ones (Ceschin & Gaziulusoy, 2016). Two innovative case studies, Poko by the Vanplestik Studio and EcoLattice by Yash Shah, showcase forward-thinking approaches by integrating low-environmental impact materials with advanced Additive Manufacturing (AM) technology. On one hand, Poko is designed by recycling waste into a multifunctional, organic-shaped lamp. It employs a unique 3D print machine to process industrial and domestic plastic waste streams – thermoplastics like polystyrene (PS), polypropylene (PP), polycarbonate (PC), PETG, ABS, and PLA – enabling unique aesthetic properties, such as a glass-like feel and shades, achieved through wavy shapes and ribbed surfaces (Isola.Design, nd.). Poko's modular and durable design allows for over 90% recyclability, stimulating a circular thinking and behavior. Since the 3D print machine deals with raw materials that are slightly damaged or spoiled, the layers are moderately thick, primarily compatible with medium and large-size products. On the other hand, material designer Yash Shah's project focuses on user-customized components for the automotive sector, combining generative design methods, AI technology, and sustainable materials like the EcoLattice. This recycled thermoplastic elastomer, based on natural rubber blended within biopolymers, allows for a faster degradation process, potentially replacing traditional foam (MaterialDistic, nd.). By involving an AI to scans the driver's body, enabling the design of personalized vehicle cushions, the form evolution is optimized for the improvement of the overall

vehicle's system performance. Both projects emphasize a life cycle thinking approach in product design including its second life system, demonstrating the value of waste as new resource and valuable solutions to address the challenges of the CE transitional context.

Meso Level

According to the framework by Ceschin and Gaziulusoy (2016), this third level focuses on integrating services into new product design. The analysis (Fig.4) delves in the MX3D project (Wynne, 2022) by the Dutch start-up MX3D, which utilized large-scale 3D printing to create complex architectural elements while improving urban safety. The project exhibits the implementation of advanced technology in large-scale structures that enhance the built environment. This large sculpture is an innovative 3D-printed metal pedestrian bridge crossing an ancient canal in the Amsterdam city without supporting structures need. Its high-tech design with curved, raw steel balustrades reshapes a futuristic city through parametric modelling. The footbridge has an organic-shaped design obtained through several design iterations – to solve the structural complexity of the original proposal – aimed at combining structural integrity and functionality for public use without compromising its aesthetic for the urban landscape. The performance of the additive-manufactured steel of the self-supporting bridge differs from regular steel – including lower elastic modulus (Joosten et al., 2022). It required to run many digital simulations to optimize the bridge geometry and remove exceeded material in not crucial parts/sections, allowing to overcome criticism regarding the lack of certification and structural codes of the new manufacturing process (Joosten et al., 2022). A sensitive sensor network installed along the 12-meter-long structure allows engineers to track and measure the bridge's parameters, monitoring changes over its lifespan (Kyvelou et al., 2022), enabling it to analyze the environment, interpret and react to the collected data and be upgraded to suit changes in use and ensure safety conditions. A Wire Arc Additive Manufacturing (WAAM) technique into 8-axis industrial robots was involved to perform structural re-engineering by means of computational calculations, enabling cost-efficient production. Welding robots programmed to deposit layers of metallic materials have reduced production costs by a factor of five compared to powder metal 3D printing and increased deposition speed - by more than 2 kg per hour (MX3D, ed.) - by enabling real-time control and monitoring of crucial printing parameters, such as speed and layer thickness adjustment (Joosten et al., 2022).

Macro Level

At the IV level (Fig.4), which involves creating spatial and social conditions for system-level sustainability through production and technological innovations (Ceschin & Gaziulusoy, 2016; Pereno & Barbero, 2020), a prominent example is the Zero Waste Lab project launched in Greece in 2018. This initiative establishes a sustainable design space hub for local communities to prompt societal behaviours transformation, encourage community engagement, and foster responsibility. The Zero Waste Lab promotes concrete action toward zero waste by involving citizens in responsible and conscious

consumption practices, simulating creative approaches to reducing, recycling, reusing, recovering, and remanufacturing waste. The project adopts a community-driven approach, engaging residents in the circular strategy implementation, e.g., waste management, and incorporating their feedback into decision-making processes for new urban designs and sites, bridging the gap between consolidate practice and advanced AM technologies. Equipped with a 3D printing robotic arm (Kuka), the Lab facilitates the creation of customized furniture for the urban landscape, extending local manufacturing capabilities based on users' needs and contributing to recycling tons of local plastic waste. By incorporating secondary resources into higher-value, long-lasting applications aligned with circular economy (CE) requirements, the Zero Waste Lab closes the material loop, adopts a short supply and zero waste manufacturing process, and reduces CO2 emissions. Additionally, the Lab offers a virtual space for sharing knowledge and collaboration, enabling users to customize their designs and assess their ecological impact – e.g., depending on the furniture's dimension and shape, around 125/208kg of CO2 is saved for each 3D printed product and 80/125kg of plastic is recycled. Through initiatives like 'Print Your City' (<https://www.printyour.city/>) (Dezeen, a, nd.) the project utilizes AM technology to achieve feasible and accessible circularity, combining high-variability design and reparability.

The Meta Level

The V level (Fig.4) supports socio-technical radical changes at the territorial scale involves profound implications across social, cultural, ecological, productive, and technological dimensions (Ceschin & Gaziulusoy, 2016; Pereno & Barbero, 2020). A noteworthy initiative exemplifying the level implications is the Erosion Mitigative Units (EMU) by Alex Goad and the Reef Design Lab (Dezeen, b, c, nd.). This innovative solution addresses environmental protection by introducing a 3D-printed marine infrastructure to re-farm coral reefs, acting as a breakwater against sea waves and combatting coastal erosion along the Australian coasts. EMU consists of submerged unit modules designed to provide a habitat for marine life while concurrently safeguarding coastal regions, enhancing the relationship between natural and built systems. The project ensures affordability and robustness by utilizing locally sourced oyster shells and a low-energy eco-concrete mixture including by-products like furnace slag and fly ash (Dezeen, c, nd.). The company involves advanced 3D printing and casting technologies to create complex structures with caves, tunnels, and porous surfaces, fostering the colonization of diverse marine species such as shellfish, sponges, coral, and mussels. The digital framework of the modules undergoes eco-engineering aligned with safety regulations, incorporating a digital moulding analysis and reusable moulds. The project adopts a long-term strategy by employing a multidisciplinary team for development, implementation, and monitoring. Crucially, EMU promotes inclusivity by engaging local communities in the care and maintenance of the marine infrastructure, fostering collaboration and learning. This nature-based, inclusive, and consciously designed initiative acts as a catalyst for environmental and social changes, contributing to the well-being of ecosystems.

Discussion

Regarding circularity, the study recognizes viable solution as i) higher-value circular design; ii) the use of local resources – in terms of energy, materials, as well as society and knowledge; iii) the design of long-term horizon according to social and environmental affordability. Regarding the catalyst role of Design in prompting and facilitating sustainable socio-technical changes (Earley, 2017), results display in the first level how alchemic capability boosting synergic collaboration between artificial and natural systems and interdisciplinary arrangement can allow designers envisioning product with reacting agency, enabling changing environmental conditions responses. The second level of the ICF model demonstrates how a forward-looking approach values the second life of materials through a more conscious choice of materials and a design option for reusing products. In the next level, a back and foreword process, commonly used into design methods, enabled to solve bridge criticisms, focusing its design on pedestrian safety and its integration in the skyline with newest computational aesthetic language that maintain the archetypal bridge essence. The fourth level displays how co-design and stakeholder involvement in the design process make circular practices accessible and disseminated by enhancing bottom-up strategies and promoting a culture of sustainable habits. Concluding, the last level showcases redesigning of the human-nature relationship within the framework of local environmental possibilities and social system empowerment as a long-term strategy for the well-being of all living species.

Conclusion

The critical role of design in shaping sustainable futures lies in integrating principles of circularity, localism, long-term thinking, interdisciplinary collaboration, stakeholder engagement, and redesigning the human-nature relationship. Through thoughtful and innovative design interventions, a more sustainable and resilient society can be achieved where resources are used efficiently, environmental impacts are minimized, and communities thrive in harmony with nature. Examining relevant case studies provides concrete examples of how additive manufacturing (AM) technology, coupled with circular principles, can be applied across various levels, from product design to socio-technical systems. Utilizing the ICF model, the study outlines broader implications of AM adoption for design across social, cultural, ecological, and technological dimensions.

However, it is essential to address challenges associated with AM processes, including:

- Conducting holistic environmental impact assessments that encompass usage phases and social impacts to better mitigate ecological implications.
- Adopting a systemic-thinking mindset to leverage local collective knowledge and actions for long-term sustainability.
- Providing open and suitable contexts for society by making AM processes more affordable and empowering local actors in redesigning sustainable management patterns.

- Standardizing more circular materials for sustainable AM strategies to meet current and future societal needs, exploring opportunities such as 4D printing and animated materials that can adapt autonomously to the environment.

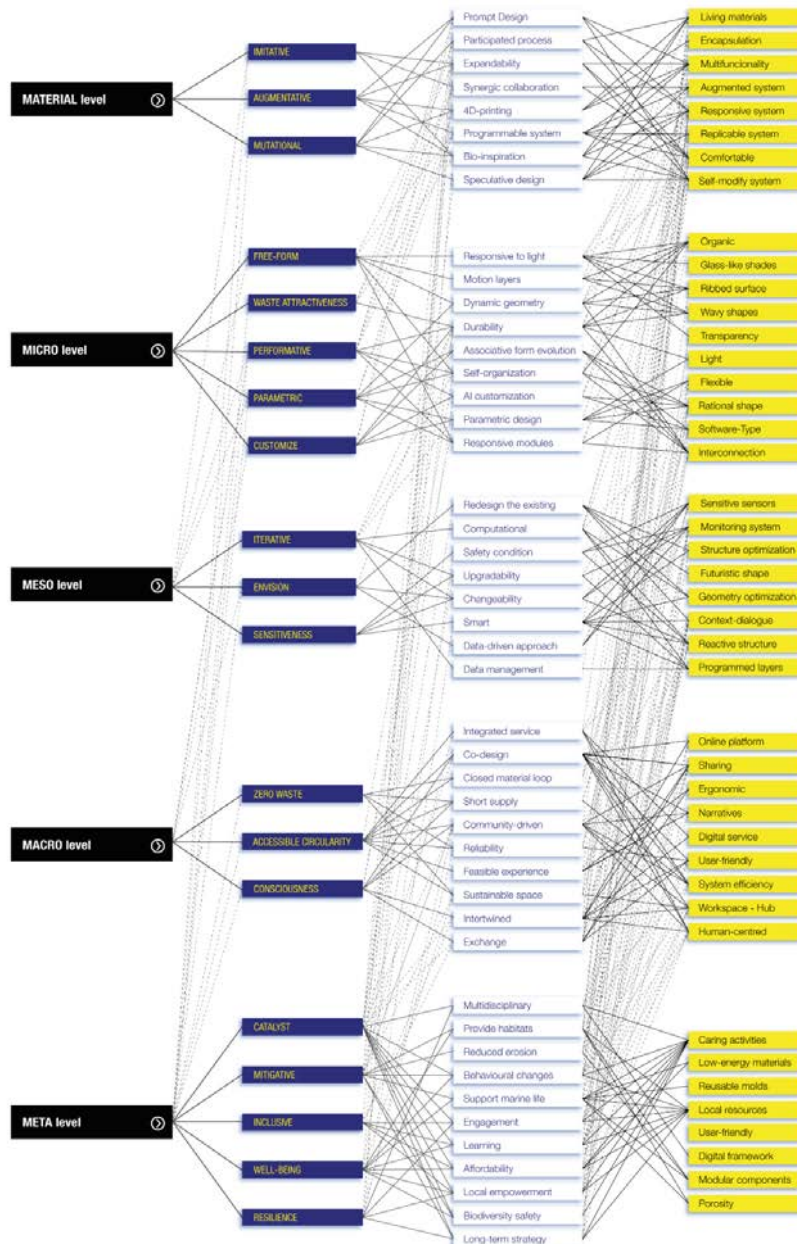


Figure 4: The ICF model consists of a semantic analysis of real-world examples, where issues (blue boxes) are the intrinsically depicted objectives and the problem(s) of the project that has been solved or need to be reached; the concept (white boxes)

While the study examined a few cases related to AM for circular economy (CE) context, it acknowledges that these examples may not be exhaustive but provide a starting point for expanding specific research areas. To manage the complexity of interconnected relationships, future studies may deepen the analysis by integrating digital software to manipulate data more effectively as design research evolves.

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Design and R&D Process of an Autonomous Water Surface Cleaning Vehicle

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ABSTRACT

Small and medium size ports (SMPs) and marinas all over the world have transformed into destinations providing a wide range of services and events. As of today, there are over 4,500 marinas and 70% of boat charter taking place with a significant part in the Mediterranean Sea. Irrespective of marinas and SMP's size and location, they are increasingly becoming epicenters of economic and social interactions. This growth's accompanying expansion in services and activities could have a negative impact on the marine environment. Factors of pertinence encompass population density, urbanization dynamics, wastewater treatment protocols, and the management of sewage sludge, each wielding considerable influence upon the generation and disposition of this waste stream. It is therefore imperative to underscore the exigency of adopting a global imperative to curtail plastic consumption and production, in recognition of its pivotal role in ameliorating the potential negative impacts upon the marine environment. Marine pollution is caused by land-based and ocean-based sources, including improper waste management, industrial discharge, shipping operations, and plastic waste. In excess of 80% of marine waste finds its source on land, and a greater volume of debris is deposited therein by the agency of wind, precipitation, or human negligence, in comparison to the quantity introduced into the seas and oceans. An overwhelming ranging from 45% to 95% of the waste littering the Mediterranean's open waters, seabed, and coasts is comprised of plastic. Hence, out of the total plastic waste 57.2 million generated in Europe in the year 2021, merely one-third undergoes the recycling process. The predominant portion of waste found within ports, marinas, and canals is subject to dispersion by prevailing currents, effectively reaching arduous-to-access sites such as the interstitial spaces between vessels and beneath docks, among other locations. Urgent action is needed to tackle plastic waste's harm to marine life and human health. Regulations, sustainable practices, and clean-up efforts are crucial for protecting oceans and ensuring a sustainable future. Current disposal methods rely on human intervention, but these wastes pose risks to health and safety. In addition to that, conservative approximation suggests that the presence of marine plastic in the oceans in 2011 resulted in a 1-5% reduction in the delivery of marine ecosystem services, leading to an annual loss of \$500-\$2500 billion in the value of benefits derived from these services.

Therefore, it is imperative to gather and observe waste in close proximity to emission sources prior to its dispersal into the marine environment. In this regard, technological progressions, exemplified by remote sensing and autonomous marine vehicles, assume a pivotal function in environmental surveillance and administration. Remote sensing methodologies, encompassing satellite and aerial remote sensing, facilitate the real-time acquisition of data concerning marine debris, thereby aiding the development of efficacious mitigation approaches. Autonomous underwater vehicles (AUVs) and unmanned surface vessels (USVs) are increasingly used for marine monitoring, mapping ocean floors, and collecting environmental data. The future of autonomy in the maritime industry lies in Autonomous Water Surface Vessels (ASVs). ASVs are becoming smarter and more automated, capable of waste collection, environmental data collection, and water quality monitoring which market in terms of volume is expected to grow at the rate of 26.7 percent during the period 2024-2035 and ultimately generate a revenue of \$3.48 billion by 2035. These vessels have promising applications in urban environments, contributing to waste management and temporary infrastructures. The integration of design thinking, particularly the Double Diamond Model, plays a crucial role in addressing complex problems like marine pollution. Design management enhances project organization and coordination, promoting efficient time management and risk mitigation.

The principal aim of this study is to provide pragmatic insights for integrated coastal and marine management, demonstrate the usefulness of the Autonomous Water Surface Cleaning Vessel in supporting the implementation of environmental goals, and discuss the opportunities and challenges associated with Autonomous Vessel technologies. This research also focuses on the integration of technology, design thinking, and sustainable practices in the design of an Autonomous Water Surface Cleaning Vessel capable of detecting and collecting waste in water bodies. By aligning the narrative of the design's research and development with the Double Diamond Model, based on divergences and convergences forming a generic Design with R&D process as well as aiming to make a substantial contribution to practice-based design research in general.

Keywords: Autonomous vessel, Autonomous Water Surface Cleaning Vessel, Design method, Marine, Marine waste, monitoring

Introduction

Problem Definition

Water pollution is mainly caused by urbanization, industrialization, agriculture and the increase in human population observed in the last century and a half, and this increase in waste threatens the existence of life day by day (Goel 2006). According to the "Goal 14: Life Below Water" report, Goal 14, one of the United Nations' Sustainable Development Goals (Goals 2023), ocean and marine life are under threat due to pollution. The prevention and reduction of all forms of marine waste from land-based activities, particularly marine waste and nutrient pollution, is crucial for sustainable development

by the year 2025 (United Nations 2003). Many international, municipal, and non-governmental groups have been concerned about environmental issues as a result of the growing human population and the climate crisis, particularly in recent years. Much of this solid and liquid waste is swept away, turning our seas and oceans into garbage soup and sometimes coalescing to form floating piles of garbage. (Denchak 2018). However, reducing and managing this pollution is crucial for a sustainable ecosystem.

While marine technologies may have the potential to solve such problems, the vessels of the future may have the potential to manage this type of waste without human intervention. With Industry 4.0, which offers automation to all sectors, it is possible to automate the waste management process (Phirke, Patel, and Jani 2021). While plastic waste capture devices can help reduce the flow of plastic waste from freshwater, at-source management of plastic waste is also needed to ultimately clean up our oceans and waterways (Helinski, Poor, and Wolfand 2021). Utilizing technological solutions to ensure water and waste management, an understanding of site conditions, community involvement, and a long-term maintenance plan are important for a sustainable marine environment.

The primary objective of the research endeavor is to assess the evolution of the development progress within the context of the double diamond design thinking model, focusing on the R&D process of a Small-Craft vessel supported by artificial intelligence algorithms capable of autonomously discerning, gathering, and effectively managing waste materials across diverse environmental settings.

Framework and Scope

To address the problem of marine waste floating on water, this project proposes the design of an autonomous water-cleaning vessel that can detect and collect waste in water bodies. The main goal of this research project is to address the challenges posed by waste accumulation in different areas, rivers and other canals, lakes and reservoirs, and near-shore coastal waters such as ports, harbors and estuaries. By combining both advancements in robotics and AI, the project seeks to create efficient and effective solutions for cleaning up these areas while minimizing human intervention and maximizing the efficiency for a lesser carbon footprint.

The design mythology consists of hull design to estimate hydrodynamic performance, 3d models printing, hardware component and preliminary evaluation of semi-autonomous capabilities. The paper represents the prototype-based model to evaluate object-based water surface waste capturing, path planning and collision avoidance.

Coastal and Marine Environmental Management

With the global population rapidly increasing and a significant portion of it residing in cities, the challenges associated with urbanization, transportation, and environmental degradation are on the rise (United Nations 2018). Recognizing the pressing need to tackle marine pollution, the United Nations' Sustainable Development Goals (SDGs) play a

pivotal role. Goals 6 (Clean Water and Sanitation) and 14 (Life Below Water) are of particular significance. Goal 6 focuses on providing clean water and sanitation to all individuals while emphasizing the importance of preventing water pollution, including pollution that eventually reaches the oceans (Prata 2018). It promotes sustainable water resource management, efficient wastewater treatment, and pollution prevention measures to reduce the influx of pollutants into various water bodies (Walker 2021). Goal 14 centers on the preservation and sustainable use of oceans and marine resources, with a specific focus on mitigating marine pollution, primarily originating from land-based activities. The international community acknowledges the need to reduce floating plastic debris for the sustainable utilization of oceans. Goal 14 sets the objective of averting and significantly diminishing marine pollution, including marine debris and nutrient pollution, by the year 2030. This goal's significance lies in recognizing the crucial role that thriving marine ecosystems play in upholding biodiversity, livelihoods, and the overall well-being of the planet.

Causes and Impact of Marine Pollution

Marine pollution arises from a complex interplay of land-based and ocean-based sources.

Land-based Sources

Land-based sources like agricultural runoff, urban runoff, industrial discharge, and poor waste management (Vogel et al. 2019), degrade coastal areas. Agricultural runoff, a major nitrogen and phosphorus source, causes harmful algal blooms and water quality decline. Pesticides from farming pose further risks to marine life. Urban runoff carries pollutants like oil, heavy metals, and chemicals into water bodies, harming marine health. Industrial discharge releases heavy metals and chemicals, impacting marine organisms and fisheries. Improper waste disposal harms ecosystems and tourism. Mitigating land-based pollution is vital for protecting marine environments and coastal communities.

Ocean-Based Sources

Ocean-based sources of pollution include shipping, oil and gas exploration, aquaculture, tourism, and marine litter. Shipping operations, encompassing oil spills, ballast water discharge, and air pollution, are one of the primary contributors to ocean-based pollution. Oil and gas exploration pose risks due to accidental oil spills, oil rig leaks, and drilling mud discharge. Aquaculture operations release pollutants like fish feed, chemicals, and waste into the marine environment. The tourism industry's activities, including sewage discharge and habitat disruption, can contribute to pollution, as does marine litter, particularly plastics. Ocean-based pollution poses substantial threats to marine ecosystems and human society, warranting comprehensive strategies for mitigation.

Impact of Marine Pollution

Marine pollution has far-reaching consequences, affecting marine life, economies, and societies in various ways. The severity of these impacts varies based on the specific

species, environmental conditions, and geographic location (UNEP - UN Environment Programme 2015). Ecological damage to marine ecosystems is one of the primary consequences. Pollution can physically harm marine organisms or alter their habitats, leading to a loss of biodiversity. Pollutants can enter the food chain, accumulating in the tissues of fish and other marine animals, posing health risks to humans. Economic impacts encompass the loss of fisheries, decreased revenue from tourism, and damage to shipping infrastructure. The fishing and tourism industries, crucial for coastal communities, face significant challenges due to marine pollution (Qian et al. 2015). Marine pollution also has social implications, including the loss of cultural heritage, reduced recreational opportunities, and public health concerns. Furthermore, it affects the safety and health of individuals. Consequently, the multifaceted impacts of marine pollution underscore the urgency of adopting comprehensive strategies for mitigation.

Marine Problem in Türkiye

The Mediterranean region of Turkey serves as the primary source of waste, with 95% consisting of plastic (Alessi 2018), where Turkey disposes of 144 tons of plastic daily into the sea. Spain and Italy contribute 126 and 90 tons per day, respectively. Factors like urbanization, tourism, and industry exacerbate pollution, notably in the Black Sea and Aegean Seas, facing significant environmental issues due to pollution (Borysova et al. 2005). Household waste, wastewater discharge, agriculture, port activities, maritime traffic, and river inflow also contribute, especially in the Aegean Sea. Pollution, exacerbated by natural variability and climate change, is a major concern in the Black Sea, requiring urgent action to protect its ecosystem (Levent et al. 2018). In the Mediterranean Sea, marine litter, especially micro-fibers from shipping, fishing, and tourism, poses significant threats, necessitating more research and sustainable practices (UNEP 2012). Izmir Bay in the Aegean region faces pollution from domestic and industrial effluents, (Kucuksezgin 2011) requiring effective management strategies to mitigate water quality degradation and eutrophication. Nutrient inputs from the Gediz River significantly impact the bay's water quality, affecting the local marine ecosystem. Coastal development and waste accumulation further exacerbate environmental challenges, necessitating better waste management practices and data collection to address environmental and health risks effectively.

Marine Environmental Management Strategies

Improper waste disposal in coastal areas can lead to pollution of beaches, water bodies, and marine ecosystems. This has a detrimental impact on biodiversity, disrupts aquatic life, and contributes to the degradation of the local environment. Traditional manual waste collection methods require significant labor and resources. Municipalities need efficient and cost-effective solutions to manage waste effectively.

It is essential to gather adequate data through dependable monitoring techniques, and managers should communicate about their monitoring approaches to ensure their suitability for management requirements. There is a pressing requirement for precise,

economical, and easily accessible solutions to guide management, at the appropriate level (Dietze et al. 2018). Automation and AI, especially machine learning (ML), improve decision-making and adaptive management in conservation by efficiently collecting, transporting, and analyzing data. Despite knowledge gaps, their implementation in conservation management can lead to successful outcomes for managers. Thus, there is considerable potential for enhancing monitoring and management in marine science through AI and automation. Studies show that revolutionary monitoring techniques utilizing automation and AI have substantially reduced operating costs by 99% compared to conventional techniques, while processing data 200 times faster (Ditria et al. 2022). Deep learning algorithms efficiently process large image-based datasets, aiding managers in making informed decisions about conservation management. Ecosystem management stands at the forefront of sustainable stewardship, employing a set of core principles and recurring themes to navigate the complexities of marine environment. These strategies are designed to foster harmony between ecological health, societal well-being, and economic considerations (Farmer et al. 2012).

Ocean ecosystem management is also significant management which relies on an ecosystem-based approach, emphasizing interconnectedness and holistic management (Sardà et al. 2014). Integrated monitoring and research utilize technology to gather comprehensive data, focusing on principles like ecosystem-based management and collaborative decision-making. Common themes such as biodiversity conservation and climate resilience contribute to safeguarding ocean health for future generations.

Marine Environmental Management Technologies

Coastal and marine management face challenges arising from insufficient data and limited data access in many countries. Effectively managing these intricate social-ecological systems requires the implementation of tools and frameworks capable of addressing and integrating multifaceted issues (Maximenko et al. 2019). Remote sensing technologies, (Figure 1) encompassing satellite remote sensing, aerial remote sensing, unmanned aerial vehicles, unmanned surface vehicles, unmanned underwater vehicles, and static sensors as ground methods, are increasingly being employed to monitor coastal and marine environments.



Figure 1 - Conceptual diagram summarizing the main activities in coastal and marine environment management technologies (Source: Mahrads et al., 2020a)

Advanced sensing and information and communication systems technologies that make up the technological network offer more efficient and various parameters with the existing infrastructure evaluation and modeling systems.

The Impacts of Marine Waste Collection and Monitoring Technologies

Monitoring the sources of marine litter requires regular surveys and analysis, considering local weather conditions and coastal geomorphology which harmonizing monitoring methods and reporting categories across different environmental compartments is crucial for accurate source attribution (Galgani et al. 2011). Studies have shown that Machine Learning can help handle the labor-intensive challenges of acquiring empirical data on microplastics, providing more data to improve models and aid in monitoring and optimizing data sampling and collection (Marin et al. 2021). The Venn Diagram designed by Helinski (Helinski, Poor, and Wolfand 2021) provides a framework (Figure 2) for understanding plastic waste capture devices in freshwater and coastal water bodies.

In (Helinski, Poor, and Wolfand 2021) classification of waste management devices, three main components are identified: Boom, Receptacle, and Watercraft Vehicle. Booms serve as barrier devices to divert or halt the flow of waste, Receptacles are containers for accumulating and holding waste, and Watercraft Vehicles are floating structures designed for travel on water. The devices are categorized based on the number of components they incorporate: stand-alone devices use one component, synergistic devices use two, and all-inclusive devices utilize all three components. The study highlights that all-inclusive device, incorporating booms, receptacles, and watercraft, exhibit a more intricate design system compared to stand-alone or synergistic counterparts.



Figure 2: Helinski's Venn Diagram (Source: Helinski, Poor and Wolfand, 2021)

Unmanned Surface Vessel Technologies

USVs are autonomous or remotely operated vehicles that navigate and perform tasks on the surface of water without the need for human intervention in real-time which possess a variety of sensors, navigation systems, and on-board computers, enabling them to operate and navigate effectively in diverse water conditions (Jorge et al. 2018). Unmanned vehicles have emerged as a valuable tool for marine monitoring. They offer advantages

such as improved safety, repeatability, reduced costs, and the ability to operate at long distances beyond human observers' detection ranges (Heo, J., Kim and and Kwon 2017). Over the past decade, unmanned vehicles have evolved and been used in various studies, including oceanographic and meteorological data collection, sea ice monitoring, and wildlife monitoring and have also found applications in the Oil and Gas industry for subsea equipment inspections, leak detection, and marine mammal monitoring.

The real-time collection of data and its integration with autonomous marine technologies will greatly contribute to the smart infrastructure of the marine environment and operational efficiency. Autonomous vessels can open additional possibilities for upgrading marine and coastal environment consider ensuring cost-effectiveness in the manage, design, delivery, operation, and maintenance of large infrastructures and networks, by adopting risk-based approaches and network resilience perspectives. These vessels applications of Autonomous water surface Vessel, although still in its early stages, have the potential to manage and monitor many types of waste that may be found on shores and at sea, including microplastics as well as many other wastes (Mahrad et al. 2020). In addition, these technologies have been used to monitor water quality status and ecosystem status, in relation to environmental management.



Figure 3 - Mayflower (Left), The WasteShark (right)

Initiatives for surface waste collection and monitoring are growing, exemplified by the Wasteshark by RanMarine (Figure 3). Integrated with scientific principles and technological advancements, RanMarine aims to benefit marine and maritime sectors sustainably while addressing climate change challenges (Frank Kirchner 2018). The Wasteshark not only collects waste but also gathers valuable environmental data through incorporated sensors. Programmed with GPS points in high-traffic areas like marinas, ports, and shorelines, it efficiently operates in waste-prone regions. Another notable example is the Mayflower Autonomous Ship, conceived to investigate global oceanic climate change impacts on marine life. Equipped with advanced image processing technology, including an IBM computer vision system, it stands out in autonomous maritime exploration, aiding in understanding climate change impacts and providing a model for sustainable data collection and risk mitigation in future endeavors (Shams 2021) (Wilcox 2022).

Evaluation of Unmanned Surface Vessel R&D with Design Thinking and Double Diamond Design Process

The Double Diamond model expands on our existing innovation framework by highlighting the context in which it operates before seeking the solution as a key component of the systematic design process, recognizing its complexity in production, and providing people and the environment equal value ('Beyond Net Zero: A Systemic Design Approach' 2021). It consists of four phases: Discover, Define, Develop, Deliver. These methods assist and provide guidance in mapping and planning the design process. Developments in innovation are also tightly connected to changes in design, where new technology, new markets, and new organizational structures in business lead to the creation of new circumstances that push for new design methods and principles. Design is in the role of an interpreter, collaborating between different disciplines, bridging technological research and innovation and their application to social practice ('Beyond Net Zero: A Systemic Design Approach' 2021). The autonomous water surface cleaning vehicle project developed using the Double Diamond design process (Figure 4) examined, analyzed, and discussed in terms of its research, design, applicability, and suitability for this given project. This project, which is being carried out in accordance with the 17 UN Sustainable Development Goals, is directly related to targets 6 (Clean Water and Sanitation), 14 (Education), and 15. (Life below water).

Based on the systemic approach, the Double Diamond model is used as a framework for systematic design process, emphasizing the importance of context, complexity, and collaboration. To extend this theoretical framework, particularly in the context of the autonomous water surface cleaning vehicle project described, several complementary theoretical perspectives can be considered including **Systems Thinking** with its holistic approach to understanding complex systems by examining their interconnections and interactions. It can help in understanding the broader context in which the water cleaning vehicle operates, including environmental, social, and economic systems. This perspective would involve analyzing feedback loops, unintended consequences, and emergent properties of the system;

Sustainability Science which explores the interactions between ecological, social, and economic systems, aiming to promote sustainable development by assessing environmental impacts, promoting social equity, and ensuring economic viability in design and decision-making processes.

Agile Methodology, commonly used in software development, emphasizes adaptability, collaboration, and continuous improvement. Applying agile principles to the design and development phases can enhance flexibility and responsiveness to changing requirements and stakeholder feedback. As well as **Design Thinking** complementing the Double Diamond model by focusing on human-centered design and iterative problem-solving. It emphasizes empathy, ideation, and prototyping to create innovative solutions that meet user needs. Integrating design thinking principles can further enhance the effectiveness of the systematic approach to the project development.

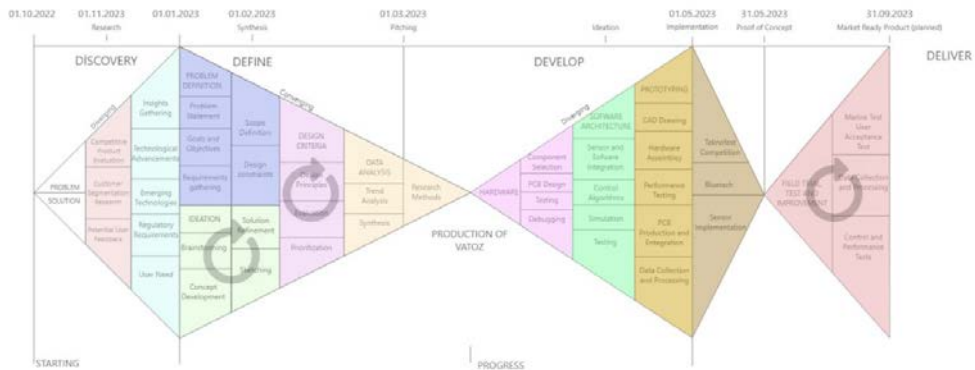


Figure 4 - Double Diamond Model Timeline

Discover (Research Phase):

During this phase, an exploration of customer segmentation, competitive products, user feedback, technological advancements, and regulatory requirements was undertaken. The initial step involved the investigation of extant technologies utilized for the mitigation of marine pollution and the examination of contemporary methodologies employed in the collection of marine waste. Subsequently, key stakeholders in the local vicinity, with a primary focus on İzmir, were actively engaged to substantiate the commercial viability within the Turkish market and to validate identified pain points. These pain points primarily revolve around challenges associated with waste management, environmental conservation, and the judicious utilization of resources. The discerned necessity for an economically viable, efficient, and low-maintenance solution for marine debris was thus established.

Define (Synthesis Phase):

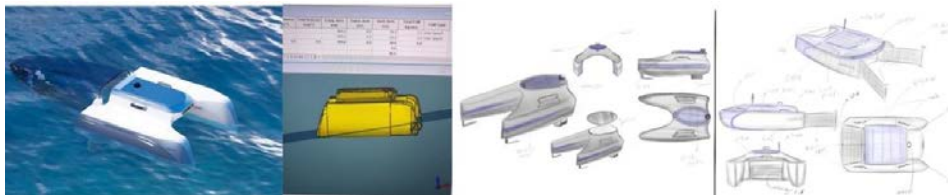


Figure 5 - Design iterations and Analysis

In this phase, design processes were initiated to optimize product development, while concurrent discussions were ongoing to validate the market. Moreover, with the increasing number of discussions, a pivot in the utilization segment related to Vatoz's research segment model was executed, leading to the determination that waste collection emerged as a more prominent issue. The formulation of the product's benefit model, aligned with the prevailing problem, has culminated in the identification of specific

software, hardware components, and design iterations deemed essential. The project scope comprehensively covered mechanical, electrical, and software systems, encompassing the design of hardware architecture, communication diagrams, and the evaluation of the vessel's superstructure, hull, and autonomous cleaning operations. The design team collaborated with engineers to delineate design criteria, requirements, and key features for the vessel. Prior to the physical model implementation, a series of continuous simulation tests were conducted, and prototypes were developed to iteratively refine the design in a three-dimensional environment, as illustrated in (Figure 5).

Develop (Ideation Phase):

This phase primarily entailed the (R&D) aspects of Vatoz. A systematic procedure was established, encompassing component selection, Printed Circuit Board (PCB) design, hardware testing, and debugging. Selected components were integrated into the Vatoz system, refining hardware functionality. Subsequently, a prototyping phase was executed to generate a tangible Vatoz prototype. Following this, attention was redirected towards software architecture, sensor integration, and the development of control and image recognition algorithms, as illustrated in (Figure 6). Simultaneously, the design of a Navigation and Status application was developed with the implementation of a software architecture conceived during the Define phase. This application enables the visualization of control and status data pertaining to the Vatoz. The software architecture, originally devised in the Define phase, has been seamlessly integrated into the application, encompassing various components such as Pitch & Yaw, Battery Percentage, Alert Menu, Live Camera, Heading, Waypoint Mission, among others.



Figure 6 - Hardware and Software Tests

Deliver (Implementation Phase):

The Field Trial Tests (Figure 7), designed to validate the Vatoz, underwent static and dynamic test series. These assessments were conducted in the Izmir Marina and municipality to evaluate the vessel's performance, safety, and functionality across diverse conditions. The autonomous movement tests within the developed application signify a fundamental level of autonomy, wherein the vessel navigates to user-specified points and collects predefined objects along the designated route. Consequently, objects specified according to user preferences along the predetermined route are collected during the autonomous navigation tests. The deliver phase ensured market launch readiness by refining the vessel based on experiences and test outcomes that validated Vatoz feasibility.

and functionality. Our endeavors were guided by adherence to the double diamond model, a framework previously employed and anticipated. In contrast to the define phase, the development phase concluded with notable expeditiousness, underscoring once again the critical importance of comprehensive research and meticulous planning.



Figure 7 - Sea Trials and Software Hardware Tests

Conclusion

The overarching objective of the project was to devise an electric-powered solution utilizing artificial intelligence (AI) for the identification and collection of debris in shallow water locales inaccessible to manned vessels, with the concurrent aims of economizing time and fuel and mitigating worker safety risks in vessel operations across lakes, canals, rivers, ponds, and port areas. This endeavor aspired to provide a portable, lightweight, and compact product service while conceptualizing a garbage pickup robot. The envisioned service sought to enable autonomous or remote cleaning of surface wastes in a secure manner within areas proximate to vessels in ports and marinas, pontoon areas, and regions challenging for the user to access. The specific focus on marine waste emanating from streams entering marinas addressed a pertinent challenge faced by marina managers, rendering the Autonomous Water Surface Cleaning Vessel a potential solution. Observations thus far indicate the successful transmission of Vatoz's position and orientation data to the user interface. The subsequent objective is to enhance the accuracy of these data transmissions, thereby advancing the level of autonomy to ensure seamless Vatoz operation without requiring user intervention.

Vatoz offers a promising solution for more efficient sea pollution collection through autonomous cleaning, yielding environmental benefits such as improved pollution prevention, climate impact monitoring, and reduced labor intensity. It is projected to have a net climate impact of -322 t CO₂eq compared to a Floating Solid Waste Collection Boat (FSWB) in 2024. In contrast to manned water surface cleaning vehicles, the Autonomous Water Surface Cleaning Vessel targets cleaning sea surface waste, surface oil, and foam in shallow water areas. As an alternative to FSWB, Vatoz decreases the typical requirement for 382.5 tkm of FSWB, resulting in a reduction of GHG emissions by 847 kgCO₂eq (IdeMat). The production of every ton of Floating Solid Waste necessitates 1.2 kg of Lithium-ion LiFePO₄ battery (118 Wh per kg), resulting in GHG emissions of 113 kgCO₂eq (IdeMat).

The ongoing research project, Vatoz, deviated from the initially planned double diamond method and instead adopted a linear trajectory with distinct phases outlined in predetermined work packages. Throughout this comprehensive project, designers' collaboration with engineers, facilitated by intensive interdisciplinary interactions, was crucial for establishing a shared understanding. This shift was driven by customer feedback and the identification of disparities in production functions. The iterative design approach has proven valuable for both designers and engineers in research and development (R&D) activities. The compact size of our design and engineering team has expedited decision-making in iterative design, production, and testing processes. Aligned with the Vatoz initiative, the unmanned surface cleaning vessel contributes to the protection of marine ecosystems from the impacts of pollution, particularly from emerging contaminants, and has been validated for potential usage in İzmir, Turkey. The project has designed and tested solutions for integrated waste collection assessment and the evaluation of impacts from emerging contaminants in the marine environment, with future examinations focusing on monitoring impact.

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Bridging the Paradox: Exploring Trajectories for Sustainability in Digital Design Education and Practice

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ABSTRACT

This paper explores and examines various approaches to the implementation of carbon-awareness within digital design education and the wider industry. It emerges from a collaboration between a group of digital design lecturers and an industry partner.

The paper delineates a two-phased methodological approach. The first phase involves an array of exploratory activities, including literature engagement, industry collaboration, and the integration of sustainability in educational settings. These activities are directed towards influencing design practices from the early project stages and addressing the intangible nature of digital products' environmental impact. The second phase entails a critical reflection on the experiences and outcomes derived from these activities.

The research synthesizes five actionable insights, including the imperative of early incorporation of sustainability in projects, the power of industry-wide collaboration, client education on sustainable web practices, the cautious use of safeguards, and a critical assessment of data tracking practices. Future directions suggest the potential of communication campaigns, dialogue tools for agency-client interaction, a reevaluation of the 'flat rate' internet pricing model, and an ethical reflection on integrating industry experience within education. The findings contribute to the discourse on sustainable digital design, underscoring the need for a proactive, holistic approach that spans educational, professional, and policy-making spheres. The paper calls for ongoing research and action, encouraging the design community to embrace sustainability as a foundational value in digital projects, thereby addressing the digital design paradox at its core.

Keywords: Digital Design, Digital Sustainability, Industry Collaboration, Design Paradoxes.

Introduction: The paradox of Digital Design

As practitioners and educators in the field of digital design, we are confronted with a paradox. On the one hand, the internet – a product of digital design – contributes significantly to the global carbon footprint.¹ On the other hand, it serves as a powerful tool that not only facilitates reductions in carbon footprints but also aids in developing novel insights into sustainability across various sectors.

This paper is one of several products to come out of a sustainability endeavor at Copenhagen School of Design and Technology. An endeavor that in 2022 led us to the disheartening realization that we, at our Multimedia-Design education, for years, have been inadvertently teaching students to make websites that are more resource-intensive and, thus, more environmentally detrimental than necessary. Determined to reverse this trend, we have posed critical questions to ourselves: 'Can we, with our position as both a research and educational institution reduce the climate impact of digital design practices? What strategies might we employ to achieve this? And where should such an endeavor commence?'

A Paradox for the Design Profession

The paradox described for digital designers extends into a broader, inherently problematic conundrum within the design discipline. Designers may be solving a problem of a situation, referring to the definition made by Simons, that “everyone designs who devises courses of action aimed at changing existing situations into preferred ones”². Simultaneously, the same designers may inadvertently trigger adverse long-term environmental consequences. Echoing Papanek’s sentiment from 1971, there is a pressing need to incorporate the ecological ramifications of design decisions. He urged for an expansion of the designer’s perspective, to transcend immediate problem-solving and consider the enduring legacy of their creations. He reminded us of the impacts of our profession by stating that “there are professions more harmful than industrial design, but only very few of them.”³ In a similar vein, Thackara lamented the lack of a robust, critical tradition within design due to its entanglement with industrial capitalism: “Because product design is thoroughly integrated into capitalist production, it is bereft of an independent critical tradition on which to base an alternative.”⁴ Such writings have spawned divergent trajectories in both design practice and academia. For example, the critical design movement may be interpreted as an attempt to develop such

¹ According to a report from The Shift Project (2019), digital technologies were already in 2019 causing more CO2 emissions than the aviation industry. Even though their calculations have been criticized by, for instance, Jan Bieser et al. (2020) for imprecise or outdated uses of data, it is still fair to say, which Bieser et al. still agree with, that the energy use of the internet is a major contributor to CO2 emissions.

² Simons (1996) p. 111

³ Papanek (1971) p. ix.

⁴ Thackara (1988) p. 22.

a critical tradition within product design⁵, likewise may research on feminist perspectives on HCI⁶, various types of design activism⁷, and the many broader types of design criticism⁸.

Bardzell and Bardzell articulate the intentions of much critical design to be challenging capitalist values: “critical design (...) holds the design profession to account for its complicity with capitalist ideology and alienation. It names some design values of global capitalism—conformity, obedience, easy pleasure, and corporate identity, among others.”⁹ Even though we do not consider our project as a form of critical design, we intent to deal with problems similar to those dealt with by critical designers and, furthermore, our intention is to question the values of our industry and explore another value with them: the value of impacting the environment less. Therefore, we define our project as an attempt (much like the above-mentioned examples of critical design, feminist HCI and design activism) to reveal how another value can contest with and perhaps even overshadow the values of capitalism that are inherent to many projects in our industry, and which in many cases are leading to choice-making without carbon emission being taken into considerations.

Methodology: Exploration and Critical Reading of Explorations

With this paper we take aim at mappin out a wicked problem and the potential solutions to it. Our approach is informed by the principles of auto-ethnography, where researchers engage in critical self-reflection, using their lived experiences within the very contexts they are investigating.¹⁰ As such, we embed ourselves in our research, acknowledging that our intimate knowledge of the industry, the technologies we utilize, and the educational programs we deliver, imbues our investigation with unique insights. Our ambition has been to influence meaningful change throughout the course of our research rather than obliging to the scientific ideals of observational detachment and distance. This paper, therefore, is underpinned by reflective notes from our engagements with Danish digital agencies, the interventions we initiated, and our consultative efforts.

Having said this, our approach is also inspired by the writings of Koskinen et al. on design research, characterizing our role as explorers seeking out multiple vantage points from which to examine the problem.¹¹ This multiplicity is crucial for unveiling new facets of the problem and, subsequently, uncovering potential solutions.

⁵ Critical design has many faces but is perhaps most often associated with the works of Dunne & Raby. See, Dunne (2006) and Dunne and Raby (2001).

⁶ See, fx Bardzell's writings on this in Bardzell (2010), Bardzell and Bardzell (2011), Bardzell and Churchill (2011).

⁷ See, fx writings by Thorpe (2008), (2012) and Julier (2013) for examples of design activism.

⁸ See, Buchanan's arguments for analyzing and developing design criticism by perceiving design as arguments (1989).

⁹ Bardzell and Bardzell (2013).

¹⁰ Hayano (1979), Maréchal, Garance (2010).

¹¹ Koskinen et al. (2011)

Consequently, this paper narrates our endeavors to shift our own focus, our students', and the wider industry towards addressing and reflecting critically on the carbon emissions associated with digital products and how such a problem might be mitigated.

We aim to elucidate, scrutinize, and evaluate the pursuit of a carbon-conscious approach to web design and development from within our professional sphere. To this end, we have reframed the central question of this conference to better reflect our own praxis as both designers and educators:

How can we, with our position as both a research and educational institution mitigate the environmental impact wrought by digital designers?

Listing and Narrating - A Two-Tiered Strategy for Work-in-Progress Research Activity Analysis

In the following sections of this paper, we will list the series of actions, we have conducted so far to reveal our progress and bring forth our narrative ways of analyzing and evaluating choice-making when having such an intention of changing our own profession from within.

Our research activities were first systematically listed and then retold in a narrative format to facilitate both empirical and critical analyses. The initial list provided a comprehensive descriptive framework, offering an empirical overview of the research activities aligned with the nature of lists as described by Schiffrin.¹² By converting this list into a narrative retelling, temporal junctures and evaluative structures were imposed, allowing for a coherent storyline that critically reflected on the sequence, significance, and impact of each activity. This dual approach enabled a comprehensive analysis: the descriptive structure of the list served as an empirical dataset, while the temporal and evaluative structures of the narrative provided a critical examination of the successes, challenges, and implications of the research activities.

By unfolding our list into a narrative retelling, we imposed temporal junctures and evaluative structures on our activities. We used the narrative structure to organize the research activities in order to, not only describe what was done, but also critically reflects on the sequence, significance, and impact of each activity. This retelling helped establish a logical progression, showcasing the evolution of our research over time, while the evaluative structures enabled critical insights into the successes, challenges, and implications of each research activity.

Critically analyzing the listed research activities through the lens of their temporal and evaluative relationships allowed the wicked problem to emerge.

¹² Schiffrin, D. (1994).

Phase One: Executed Activities

This first exploratory phase comprises numerous activities detailed as follows:

- Engaging with literature on sustainable web design and development authored by scholars, thought leaders, consultancies, and think tanks to inform our actions.
- Participating in open forums and knowledge exchange events hosted by digital agencies.
- Selecting a relevant industry collaborator for the project to ensure that our ideas remain grounded and to gain access to and, thus, be more likely to affect the industry.
- Assisting in the creation of a digital tool designed to measure the carbon footprint of a client's website.
- Conducting interviews with both our industry collaborator and other digital agencies about their current practices, the changes they anticipate, and the kinds of employees they will be looking for in the future if they are to comply with their sustainability objectives.
- Incorporating our industry collaborator into our education to encourage student projects to focus on three areas: Visualization of website carbon emissions for agency clients, design strategies for reducing website carbon footprints, and public campaigns to promote sustainable internet usage.
- Organizing full-day events dedicated to sustainability for our academic colleagues. Here, we invited our industry collaborator into our institution to inform our fellow lecturers that in the future they will be looking for employees who know about making sustainable websites. We also invited various researchers and practitioners to inform our colleagues and to discuss existing eco-conscious initiatives available to digital designers.
- Prototyped but never tested: Designing a tool for dialogue between the digital agency and their clients to help externalize the conversation and bring in dialogue about sustainability as early as possible.
- Undertaking a consultancy role to explore resistance to change among clients and to investigate barriers to aligning with stated sustainability goals.
- Compiling lists of low-carbon websites as exemplars and reasons for why they might be worthy of imitation.¹³
- Discovering initiatives from other industries that have worked well and explore whether transferable knowledge have been discovered here.
- Ideating on ways to communicate through designed prototypes and products in ways that illustrate and illuminate the problem and its causes. Also, discovering metaphors that may help turn the abstractness of the problem into images that are easier into relatable and understandable visual narratives.
- Designing exercises and activities with a carbon-conscious focus for our students, including:

¹³ See, for fx <https://lowwww.directory/>, <https://lowwwwcarbon.com/>, <https://rightsforchildren.org.uk/>, <https://lowwww.directory/> and <https://chris.bolin.co/offline/>.

- a. Construct websites with a maximum of 150 kb.
- b. Minification exercises: Reduce all that is unnecessary (for example unnecessary line breaks and spaces in code).
- c. Safeguards to limit the effects on carbon emission made by users.
- d. Organizing a 'Digital Clean-Up Day' for all.¹⁴
- e. Exercises in which all students, who wanted to participate, shared information on mobile data consumption to highlight high-emission services and websites and personal impact.
- f. Developing a communication campaign to young people about the effects of and to mitigate 'second screening'¹⁵.
- g. Visiting three prominent digital agencies who informed our students about their sustainability strategies and initiatives.
- h. Revising our curriculum to include:
 - Teaching *Astro* rather than *WordPress* to promote the use of static rather than dynamic site generation.
 - Teaching ways to use less video and more illustration.
 Promote critical discussions on 'deceptive patterns' that manipulate users and, in some cases, only serve the purpose of keeping users engaged with a site.¹⁶

These steps embody our commitment to an active, transformative research process, aiming to embed sustainability at the heart of digital design practices.

Phase Two: Categorizing Discoveries and Conducting a Critical Reading of these

Having executed the aforementioned activities, we dedicated time to reflect on our experiences and conclusions in our own group and with our industry collaborator. This phase yielded significant insights, a subset of which we will recount here, evaluating their influence on our research question and the outcomes of our research.

Engaging with Greenwood's Insights on Sustainable Design

Our first step was to dive into literature on sustainable web design and design practices that aim to change their own profession. It was through this exploration that we

¹⁴ See, www.digitalcleanupday.org.

¹⁵ Second screening is when a person, for instance, is streaming a movie while also scanning through social media on a phone.

¹⁶ One example of a deceptive pattern is the streak function in Snapchat, which serves little other purpose than to keep users engage with Snapchat and, as a result, send carbon emitting pictures to their friends again and again.

encountered the traditions of critical design and design activism, and a variety of approaches described in those. They assisted us in discovering a meaningful approach to our project in which we are trying to affect the premise (here to be understood as the foundation value) of a project.¹⁷

However, we also needed writings on more concrete actions to take within digital design. What are good ways to reduce carbon emissions of your digital design? That is how we found ourselves collectively engrossed in Greenwood's 'Sustainable Web Design'. The book is a practical guide advocating for environmentally sustainable practices of efficient web design, development, and hosting strategies to reduce the carbon emissions and energy consumptions of the digital realm. A synopsis of Greenwood's work is warranted here for the practical directives it offers, which, while compelling, posed challenges in persuading ourselves, our industry, and our academic institution to implement them.

Greenwood calls for the digital sector's commitment to environmental sustainability, inspired by John Elkington's Triple Bottom Line concept. By illustrating the immense carbon footprint of the internet, Greenwood champions a minimalist, efficiency-driven approach. This, includes design practices like optimizing imagery through efficient file formats and compression, using darker color schemes to reduce energy consumption, and advocating for restrained use of motion and animation. According to Greenwood, such practices not only advance sustainability but also enhance user experience and accessibility.¹⁸ The book also advocates for greater attention to energy-efficient development processes, spotlighting the role of efficient coding and the energy efficiency of programming languages. Greenwood encourages practices like avoiding code duplication, judicious use of JavaScript, and embracing technologies like JAMstack and Progressive Web Apps for their efficiency advantages.¹⁹ The book's exploration of green web hosting reveals the environmental impact of data centers and the significance of choosing hosting services powered by renewable energy. Highlighting the trade-offs between traditional and hyperscale data centers, Greenwood argues for the importance of using content delivery networks (CDNs) and efficient server technologies to minimize the environmental footprint of web hosting.²⁰ Finally, Greenwood addresses the integration of sustainability in organizational culture and market strategies. He emphasizes the role of sustainable web design in meeting client goals and navigating potential government regulations, advocating for sustainability as a core value rather than a marketing afterthought.²¹

Upon completing Greenwood's book, we were eager to take action, feeling both empowered and hopeful that this new knowledge had equipped us to tackle and transform the unsustainable business and design practices that we found, not just

¹⁷ This is further described in Halstrøm's article on design values (2016) and in the above-mentioned writings of Bardzell (2010), Bardzell and Bardzell (2011), Bardzell and Churchill (2011).

¹⁸ Greenwood (2021), chapter three.

¹⁹ Greenwood (2021), chapter four.

²⁰ Greenwood (2021), chapter five.

²¹ Greenwood (2021), chapter six.

ourselves a part of, but that we were also educating our students in. With a classical mix of good intentions and newfound overzealous confidence we felt ready to take on the climate crisis, one inefficient code and energy-guzzling websites at a time. It turned out though, that our quest would be less of a fixing and rescuing charge and more of a humbling and enlightening marathon.

Two examples of collaboration are particularly relevant to describe here, because they illuminate the difference between knowing what Greenwood tells us to do and then persuading our profession and our own institution to act accordingly. The first concerns our advisory role at a Danish university, while the second pertains our cooperative work with our industry collaborator.

Knowing is Not Enough and Change is Difficult

During our exploratory research, we encountered individuals and organizations in various situations who, despite recognizing the necessity for more sustainable web design and understanding the required changes, were reluctant to act. One illustrative case that we noted, occurred when we were engaged as consultants by a prominent Danish university on the cusp of designing a new website. They sought our insights from our project guidance on actionable steps. We shared relevant findings and Greenwood's recommendations, alongside a carbon emission analysis of their existing website. One significant problem was that on their front page they had an unnecessarily heavy auto-playing two-minute film clip (90 MB). This meant that most people who visited their website had no choice but to emit an unnecessarily large amount of carbon, which was in direct conflict with the intention and the explicit strategy of the university as well as their communication department. Additionally, we identified an unnecessarily excessive amount of data tracking, which amassed information beyond their interest. This illustrates an approach to tracking, which we also discovered in conversations with our industry collaborator. The attitude to tracking is that instead of asking clients about which kinds of data they need, then, the default is to offer comprehensive data tracking packages without discerning the specific needs of clients. The idea behind this is that it is better to be on "the safe side" and collect as much as possible rather than to ask: which data is relevant?

We found several other examples, but mention these two here to illustrate an insight, which we found several times through our project. When we returned a few months later to ask them about how their process was going, we could see that the large film clip was still on their front page, and they were still tracking unnecessary amounts of data. These oversights, they explained, were negligible in light of an impending new website. The point we are making here is perhaps banal but still relevant. Information about sustainability is not necessarily enough to make people go and do the changes. If it is nobody's job to go and do the changes, then they are likely to never be made. Sustainability needs to be thought of and implemented early on in a project so that it

does not become a task to go back and redo the mistakes. This finding aligns with a problem that was also discovered by our industry collaborator in our project. Below it is referred to as problem two.

While Greenwood's book served as a crucial guide for us to initiate an immediate change in our attentions towards doable sustainable practices in web-design in our work and teachings, our concrete experiences remind us of the need to engage with sustainability in web design in a more holistic manner, considering the intricate interplay of technological, societal, human, and economic factors.

Fostering Industry Collaborating for Sustainable Impact

Since one of our main goals is to affect the industry, we invited private collaborators into the project early on. Rather than seeking to be independent and develop an "independent critical tradition"²² as Thackara might advise us to do, we explore this dilemma together with the private agencies of our profession. Subsequently, we independently analyze and evaluate our efforts to discover viable ways of approaching this dilemma and look for ways to promote a sustainable value as foundation for digital design projects. We wanted to make sure that we had a reality check every now and then. Therefore, we reached out to one of the leading digital agencies in Denmark and asked them to collaborate with us on this issue. To our fortune, they were already contemplating the issue of carbon emissions, and two people were already working on a prototype to inform clients. They also admitted that they were not very far with this, and very few clients asked about climate issues in relation to digital solutions. So, the need was not present yet for them, but the two people (later three people) were interested in collaborating with us, since they were hoping for three things to happen: (1) a push from future clients, (2) potential EU regulations to comply with, and (3) a push from the industry itself.

Our initial meetings revolved around their idea for a carbon emission calculator. This was to be designed to measure a website up against the client's industry competitors rather than what most calculators did at the time of writing: measure against any other website. The current model often unfairly penalized content-rich sites like news portals for their inherent multimedia usage when compared to smaller entities. This rendered the tool of little value for such websites seeking relevant industry-specific insights.

We followed the development and implementation of this calculator and interviewed our two collaborators about this along the way. They discovered two problems, which were preventing the calculator from being as persuasive as they had hoped for.

²² Thackara (1988) p. 22.

Problem one: The calculator was challenging to incorporate into the preliminary stages of client-agency project discussions and contractual agreements. Often, the agency had created the client's existing digital solution, and highlighting its environmental shortcomings was counterproductive for the agency's business interests. It also did not serve as an ideal icebreaker to point out a client's negative climate impact through their current website.

Problem two: The calculator was better suited for evaluating a website, once it had been made, rather than predicting what it might be like and how it might perform. This meant that the agency could bring the calculator into the conversation but only when it was too late to make significant changes to the product. Once a solution had been made for the client, it was difficult to turn into a more sustainable website if the client wished for this.

We discussed several ways to solve these two problems with them. We decided on two ideas, but the agency ended up only doing the first of the two and then a new third idea which, in hindsight, was probably more effective.

1. The first idea was to illustrate the choices and the effects of choices that clients could make when they were deciding on what the agency was to design for them. For this, the agency needed ways of illustrating such choice-making. We decided that this was a good assignment for our students. Our two collaborators from the agency came and gave our students an assignment of how to visualize the data that the calculator was providing in persuasive ways to clients. The outcomes were manifold. Firstly, it raised student awareness of sustainability as a critical industry issue, which subsequently influenced their capstone projects and, hopefully, their future professional decisions. Secondly, the agency gained a plethora of visualization options, aiding them in clarifying the environmental implications of client choices. Thirdly, the student work provided a demonstrable and relevant educational activity that showcased the importance of sustainability, even to those colleagues initially indifferent to our project.
2. The second idea was to create a tool for dialogue with clients to integrate sustainability into meeting agendas. However, the agency believed that it might be more effective to not push the dialogue when inside these meetings but rather to push the industry itself to communicate about the issue of digital products and carbon emission. This led to a whole new idea, which aimed at initiating a broader industry-wide conversation on the topic.
3. Several months later, the digital agency sought to build an alliance rather than going it alone. They initiated meetings with other leading digital agencies in Denmark to decide on a set of guidelines to subscribe to as a digital agency in Denmark. This coalition transformed our once semi-clandestine endeavour into a significant movement, with the agency's director involving us in strategic

discussions. Subsequently, a landmark assembly of agencies committed to a new set of guidelines, which were the products of these meetings. We cannot claim here that this was because of us and our project. We simply do not have the data to back up such a claim, and, also, during our time of working on the project the agenda of internet carbon emission went from being new to our industry to something that several agencies posted news about on their LinkedIn-channels and did inspirational morning sessions for potential clients about. So more likely, we were a small part of a wave that many agencies suddenly subscribed to and wanted to show that they were the frontrunners of. We see no problem in that, though. Eventually, the director of the agency came back and presented their new sustainability strategy to our students and our fellow lecturers, making it clear to everyone at our institution that this was the agenda that they and other major agencies were going to subscribe to from now on, and that this was something that we as an institution should educate our students in if they were to work for an agency such as theirs.

Conclusions: Synthesis of Insights and Future Directions

Our research culminates in a distillation of five insights from our project, which may be useful to our industry and fellow lecturers in digital design committed to promoting a carbon-conscious agenda:

- ***Find ways to bring carbon emission intention into the early phases***

Our interviews with the agency and consultancy activities showed that it is more difficult to make changes in the late stages of a project than to design with carbon emission minimization in mind from early on. In tangible design realms this may be an obvious conclusion but regarding digital products it may easily be overlooked because of their ephemeral nature. Making these choices tangible may be done by means of visualizations and other forms of artifacts that can make it explicit how the choices that clients make (or the choices you decide to make together with them) will affect the carbon emission of the digital solutions they end up being the owners of.

- ***Industry-wide Collaboration can Propel the Agenda***

The best solution may not be to confront the problem head-on. Sometimes it may be more effective to look outside the situation and see if you can have someone else onboard who can help you change the situation. Our industry collaborator decided that rather than to affect the client agency conversation in one-to-one situations, and putting themselves in awkward situations where they were pushing an agenda to a client, they wanted to affect an entire industry. They

aspired to instigate a shift that would make sustainability an industry norm, not just a talking point for pioneers. So, the abstract conclusion we are making here, is that it may be better to think parallel to the situation you are in and not necessarily solve the problem head-on. This stance suggests that a lateral approach, preparing clients for sustainability discussions before actual project meetings, may be advantageous. A biproduct of this may be that in doing so it also becomes more difficult for your own agency and your fellow colleagues to not commit to the agenda, and, perhaps more importantly, the effect may be greater because more agencies comply.

- ***Educating Clients on Sustainable Web Practices***

In our example from our work with the university, our interviews with digital agencies and our analyses of various websites show that it is not only the digital designers but also the webmasters and communication departments who may cause problems. An internal protocol for sustainable operations could prevent ecologically adverse decisions like hosting large videos on primary web pages.

- ***Safeguards may Work if Communicated Well***

If the design is made in a way that makes it impossible to post two-minute videos, then, this may prevent this. However, this conclusion comes with a warning. Our industry collaborator as well as our own experiences show that in some projects this only made the users more creative about how to bypass the limitations. So, safeguards may work if people are informed about why they are there and find it meaningful to comply with them.

- ***Promote a Change of Attitude towards Tracking and Data***

Our interviews revealed that the approach to tracking was that it was better to generate as much data as possible to be on the safe side. To be on the safe side for the client and the digital agency, though, can also create unnecessary impact on carbon emissions. We cannot conclude on how to solve this but suggest ways of communicating this problem to digital agencies, clients, and perhaps also politicians since the problem behind this may be tracking and generating so much data costs so little. We argue here that solutions to this should be further explored in design research.

Looking Towards Future Investigations

- ***Advocacy through Communication Campaigns***

Our findings underscored that while students were initially oblivious to their carbon-critical activities, they engaged wholeheartedly in campaign development against behaviors like 'second screening'. This told us that communication campaigns may be a relevant option to explore. At the same time, we are also worried about the kinds of effects that campaigns may have. Will it add to a public feeling of the climate problem being too multi-faceted to be solved by individuals so that people give up on this and perhaps even other initiatives? Will campaigns create more critical users or adversaries? The answer is probably that it depends on how such campaigns are made, but this has yet to be explored.

- ***Dialogue Tools for Agency-Client Interactions***

Despite our partner's shift towards industry-wide discourse, developing conversational tools to make sustainability options tangible and explicit for clients may still be a valuable approach. As we saw in our research, it was often too late if choices concerned with sustainability were brought into a project too late. Also, the importance of it not being brought in too late was underestimated. We have therefore defined layers of professionals to be affected, and at what stage, which is to inform such tools for dialogue. This, we wish to explore in future iterations of this project. Layer one: The business analyst/salesperson. Layer two: The UX designer. Layer three: Developers. Layer four: The client and their users being the webmaster, the communication department, journalists, editors etc. Each layer plays a significant part, and one affects the other. Our tool is to reveal the effects of each of these layers on the sustainability of the digital product and their effects on each other.

- ***Questioning the 'Flat Rate' Model***

The prevalent 'flat rate' internet pricing model promotes a perception of the internet to be without limits. The costs of use are hidden by this form of payment. Whether a commercial or a two-minute video plays when you open a website does not matter to the flat rate user.

We propose a reevaluation to make these costs more transparent to the user. Additional research is needed, though, to assess the implications of such a systemic change.

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Reshaping University — Industry Collaboration with Design Thinking

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ABSTRACT

How can we make the best use of design thinking to redefine the way our business school is cooperating with industry partners? And how do our cooperations become more impact-driven? This paper outlines the development of new formats for interactions between students and companies with a co-creation approach. The results are nothing less than a paradigm shift for the faculty.

Keywords: University Collaboration, Knowledge Transfer, Career Management, Co-Creation, Sustainable Universities.

Introduction

At Hochschule München University of Applied Sciences' (HM), business school, for fifteen years, networking between companies and students mainly took place during a one-day career fair held every year on campus. The career fair was very popular among students who liked to browse the exhibitors' booths, talk to Human Resources (HR) staff about open positions, and catch a few giveaways. During the COVID-19 pandemic, a virtual career fair replaced the onsite event and was kept after the lockdowns so students could virtually browse open positions of companies 24/7. A Lean Startup (Ries, 2020) approach was applied in the past two years to continuously improve and expand these formats. The Lean Startup methodology builds on rapidly identifying and refining new ideas into models that work (Cook et al., 2022). Building something new, measuring its success, and learning from feedback is the heart of this process. Looking at the feedback from the last build-measure-learn cycle, it became clear that it was time to completely challenge the status quo, as more and more interested companies were competing for fewer students visiting the offered events.

Furthermore, for HM as for many other universities, it became a priority to develop key competencies for sustainable development (Barth et al., 2007). Acquiring sustainability literacy is important for students as well as faculty. The integration of sustainability is an ongoing task that universities have begun to address (Salleh et al., 2019) and is a key strategic effort at HM (https://hm.edu/hochschule_muenchen/nachhaltigkeit_1/in-dex.de.html). By trying to embed sustainability aspects not only into the curriculum and

university's operations but also within the framework of university-industry collaboration, universities can take a governance role in including sustainability holistically (Molthan-Hill et al., 2020; Leal Filho et al., 2021). By bringing sustainability to the agenda of university-industry collaboration, HM's business school caters to the fact that corporate sustainability has been identified as an important fifth pillar in traditional three- and four-pillar conceptual models of sustainable development, which focus primarily on social, political, environmental, and economic pillars (Greenland et al., 2022). Therefore, businesses need to consider their sustainable corporate impacts and teaming up with universities to work on this challenge lies at hand.

The industry collaboration team at HM's business administration faculty decided to build on a couple of different sources and methodologies to get feedback on and enhance its university-industry collaboration. First, as project-based learning approaches focusing on sustainability topics driven by students can create societal and environmental impact (Rajan et al., 2019), the team decided to involve students in the design of new formats. The intention was to include a dedicated project regarding university-industry collaboration into existing modules of HM's business school as this is a way to affect students' prosocial, ethical values and intentions to foster implications for responsible management education (Haski-Leventhal et al., 2022). Therefore, student teams from different courses were tasked to come up with fresh ideas.

Second, the team held a brainstorming session with a representative from the Strascheg Center for Entrepreneurship (SCE, www.sce.de), which is HM's institute for all entrepreneurship-related activities. They thought about how existing formats of SCE could be further developed to create a tangible industry experience on the business school's campus tailored to its students and sustainability topics. Third was a Design Thinking workshop with all involved stakeholders to come up with new, innovative, and sustainable ways of connecting industry and students. The reason why Design Thinking was chosen for such a co-creation workshop is that its user-centered approach has been widely used in the corporate context for the last couple of years (Marion et al., 2021). It is mainly used when the problem is unclear, the main stakeholders can be involved in the design process, and there is time to iteratively test and refine prototypes. Design Thinking is applied in HM Business School's entrepreneurship courses, which are mandatory for all students in the seventh semester. Therefore, the methodology is known to both teachers and students. In these entrepreneurship courses, students apply Design Thinking to come up with solutions in terms of business ideas including prototypes for given or selected problems. However, the authors have never used Design Thinking to develop solutions within the university, be it in teaching or administration. Allworth et al. (2021) state that as Design Thinking is about designing with users and not for users, it also aligns well with student affairs practices and can be a useful tool to disrupt higher education systems and practices. Therefore, the authors felt it was time to use Design Thinking as an additional means to develop new formats for university-industry collaboration, even though some argue that problems that have multiple stakeholders and are rather

undefined, new methodologies using a systemic (rather than user-centered) and reflective (rather than ideation-based) practice need to be developed (Verganti et al., 2021).

Methodological Approach: Case Study Research

The authors of this study are both professors at HM. The first author is teaching entrepreneurship, innovation management, and responsible management at HM's business school. The second author is teaching entrepreneurship and Design Thinking at the Department of Applied Sciences and Mechatronics and is head of digital teaching at SCE. They have jointly taught an international and interdisciplinary entrepreneurship class for the past seven semesters (Krzywonos, Maisch, Kaiser, 2023). The authors used the "research onion" by Saunders et al. (2023) to define the methodology for this research (Figure 1). The research onion was chosen as it is depicted in a simple, visual way as you "peel" the onion: which research philosophy guided the research design, which approach to theory development was chosen, which methods and strategies were used, and finally in which time horizon and with which techniques the work was conducted. As the peeling of the onion is relatively easy to grasp also for students who get in touch for the first time with scientific work, the authors and other faculty at HM require their bachelor and master thesis students to apply the research onion when describing their research setting. It is also mandatory when students want to present their research results at HM's business school's student conference on sustainability topics. For the authors to prepare a poster presentation for such a conference themselves, they applied the research onion for this study as well.

Coming from a Critical realism philosophy and an abductive approach to theory development, the authors chose mixed-method research. To figure out how interactions between companies and students could best be designed at HM's business school to meet the needs of both companies and students, a case study approach was chosen. A case study is an in-depth inquiry into a topic or a phenomenon within its real-life setting (Yin, 2018). The interaction formats between companies (industry) and the faculty's students served as this real-life setting. Data was collected from feedback questionnaires of the career fair in May 2023, from module assignments of a student cohort during the winter term 2023/24, as well as from a co-creation workshop in February 2024, therefore it was a cross-sectional study.

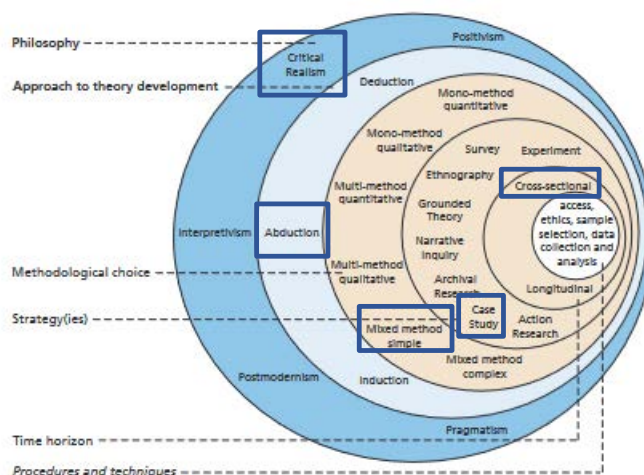


Figure 1: The research onion (Saunders et al., 2023, p.131).

Results

Initial Setting

Over the past fifteen years, networking between companies and students at HM's business school took place via guest lectures, excursions, expert talk events, and a one-day career fair on campus. Guest lectures and excursions were organized by the lecturers themselves and mainly driven by their previous careers and connections. The expert talk events and career fairs were organized by a small team consisting of administrative staff and two professors at HM who were very engaged to enable the students a smooth career start in a renowned company. This team was called "cooperations and transfer". Both event series went very well for one and a half decades. However, when COVID-19 struck, new digital ways of interaction needed to be developed. A virtual career fair with 24/7 company booths as well as a digital pitch event where companies presented themselves in five minutes was developed by the cooperations and transfer team which were accepted well both by companies and students.

In 2023, a new team started to work on "cooperations and transfer" which called themselves the "Campusconnect" team. The Campusconnect team consists of one new staff member who dedicated around 70% of her time to industry collaboration topics, one working student working six hours per week for the team, mainly dedicated to social media communication, and the first author of this paper as representative of the faculty. This team felt that post-COVID-19 it became more and more difficult to engage students to participate in digital as well as on-campus events, a phenomenon that universities are facing worldwide (Warner et al., 2023). On the other hand, there was a high demand from the companies' side to interact with students as the lack of skilled workers is prominent in all industries (Sharma et al., 2023). This led to the situation that more and

more companies were competing for a limited number of booths at the career fair (42 booths in total due to room restrictions on campus) and slots in the digital pitch and newly introduced speed dating event but was faced with fewer visitors on their booths and during the digital events. Campusconnect wanted to move away from continuous improvement on existing formats and radically rethink the way the faculty connects companies with students. Therefore, Campusconnect started three initiatives together with students (the main target group) and the Strascheg Center for Entrepreneurship to answer the following research question: *How might we connect companies and students in new networking formats that have a large reach and are carried out sustainably?*

Feedback from Students

In the first step and to include a project-based learning approach (Rajan et al., 2019), Campusconnect decided to task students from different courses offered during the winter term 2023/24 at HM's business school with projects regarding the existing career fair format. To make access to students convenient, they focused on modules facilitated by the authors, focusing on business students only as they were familiar with the existing industry collaboration formats for HM's business students. Campusconnect first asked students in an HR master program the first author was teaching to interview participants of the 2023 career fair. Students were tasked to find out how satisfied the participants were and if they had any suggestions for change. These open questions were asked:

- Why did you visit the career fair?
- How did you get to know about the career fair?
- What could be improved or what would you wish for?

26 participants were interviewed and the main feedback from participating students was that they wished for more advertising upfront on social media, as they did not know exactly what to expect from the career fair and if it was worthwhile to spend some of their free time there.

Additionally, Campusconnect asked students in a business administration class also facilitated by the first author how they would include more sustainability into the vision & mission, and strategy of the established career fair. One student group suggested Virtual Reality (VR) glasses to browse companies' premises and job insights instead of an onsite event, which would save traveling time and emissions on both students' and exhibitors' sides. Another group suggested the possibility for students to book one-on-one meetings with individually chosen companies instead of a one-day fair. A third group suggested to mainly invite companies to the fair which actively promote sustainable solutions for the future and ecological responsibility. Similarly, one group suggested introducing a sustainability questionnaire where exhibitors should rank themselves in terms of economic, ecological, and social sustainability and this ranking made transparent to all visitors. This measure would enable students to explicitly get in contact with those companies that are doing well in terms of sustainability.

Brainstorming with the Strasczeg Center for Entrepreneurship

Apart from asking students for their creative power to come up with fresh ideas for university-industry collaboration, the authors also invited a representative from SCE suggested by the second author to brainstorm on a new suitable format. Almost since its inception in 2002, SCE has been conducting a very successful event series called "Innovation Café". It is a monthly networking event taking place every first Tuesday of the month at 6 p.m. in the SCE premises in downtown Munich, offering students and university staff the opportunity to talk to the other stakeholders in the entrepreneurship ecosystem in a relaxing, informal atmosphere with a glass of beer/juice/water. A speaker, typically the CEO or founder of a successful company, is invited to talk about their founding experience, pitfalls and lessons learned, and the importance of networking in starting your own company. Participants will

- learn about the activities at SCE
- get to know the team of startup promotion or refresh contacts,
- ask questions, exchange creative ideas, or simply
- just get a taste of "entrepreneurship air".

Additionally, for existing startups, there is the opportunity to pitch their business idea and call out their needs at the beginning of the Innovation Café if they like.

Campusconnect was considering introducing an Innovation Café or similar format on the business school campus, which is situated in a quarter outside the city center. In a joint meeting with Campusconnect and the responsible manager at SCE for the event, they brainstormed whether an Innovation Café would be the right format for the business school campus. They agreed the location might make it challenging to get CEOs of scale-ups or established companies as speakers, who are typically situated downtown or in other areas of the city. However, very young teams or startups who are still seeking co-founders or staff/ working students might be eager to visit the business school campus. Vice versa, this aspect seemed to be very appealing to the business administration students. After an hour of discussion and brainstorming, the idea of a Business Model Hackathon was born. Like an Innovation Café, it will start in the evening, specifically at 5.30 p.m. after the afternoon lecturers have ended, and continue until max. 8 p.m. After a short intro of SCE, three young startups or teams will introduce their business models and present a tangible challenge for the business administration students to work on for an hour and afterward present their pitches for their solutions. The challenge will center around concrete topics the teams are struggling with regarding a specific element of their business model like marketing or sales, finance, etc. Typically, areas in which business administration students rather have a high expertise whereas most startups founded by university students come from engineering or information sciences. Thus, the Business Model Hackathon is a more interactive format than the Innovation Café, intended to bring together students and former students who are now founders, which requires the active participation of all guests as well as presenters. The first Business

Model Hackathon will take place on 30th April 2024, and if successful, will be refined and repeated every semester.

Co-Creation Workshop

Thirdly, the Campusconnect team decided to address the “How might we” research question in a co-creation workshop with all relevant stakeholders. Stakeholders were defined to be students as the main target group for all interaction formats with the industry as well as companies, who are the most important partners when it comes to interactions. By strengthening corporate sustainability as an important fifth pillar in sustainability models (Greenland et al., 2022), HM’s business school can take a holistic view and broaden its efforts to increase impact in all areas. The other two stakeholder groups were professors who play a role when it comes to company relations in terms of joint student projects, guest lectures, overall curriculum, etc., as well as university staff working in cooperation and transfer in different departments of the university, as they are key in implementing and promoting the new formats to be developed. Two to four participants represented each stakeholder group. In terms of selecting the participants, an Email was written to all industry partners whether they wanted to take part. Coincidentally, the companies that wanted to participate were quite diverse: one HR startup and one audit and tax company; one female, one male representative. Diversity on the participants’ side was much appreciated, as the authors have experienced in their entrepreneurship courses that the results in terms of business ideas are much better when teams are built interdisciplinary and diverse regarding other aspects (age, gender, nationality, area of expertise/ field of study). On the student side, two volunteers from the master’s program in Applied Business Innovation participated (both females). To recruit the professors and other faculty or university members, an email was written to all employees to ask who would like to participate. Volunteers came from cooperations and transfers, the family businesses research unit, the international office (all females), and four professors (Vice Dean International, Sustainable Management, Social Sciences, Student Dean, 3 males, one female). The workshop took place on 7th February 2024 on campus with twelve participants in total plus one moderator.

After a short welcome and introduction of the participants, the workshop moderator briefly introduced the Design Thinking methodology as well as the three teams for the day. Teams were assigned upfront to make sure every team consisted of representatives from the different stakeholder groups.

Typically, for Design Thinking projects with students, the authors use a dedicated process developed at SCE for its real project seminars which follow an “education through entrepreneurship” approach. This means that entrepreneurial principles and mindsets are acquired during the learning process along with real, practical challenges. The process is based on Design Thinking elements but goes beyond them when it comes to pitching and selling ideas. It would have been intuitive to apply this process within the co-creation workshop. However, as it was only familiar to the authors and students but

not to the other workshop participants (including other professors, staff, and companies), the authors decided to choose a methodology that is well-known and established in a lot of companies: Google's Design Sprint Methodology (Google 2024). The reason was that if participants would work with a methodology they had most likely already been in touch with, time for explanation of the process itself would be freed up for the creative development part.

Figure 2 describes the six different phases of this methodology.

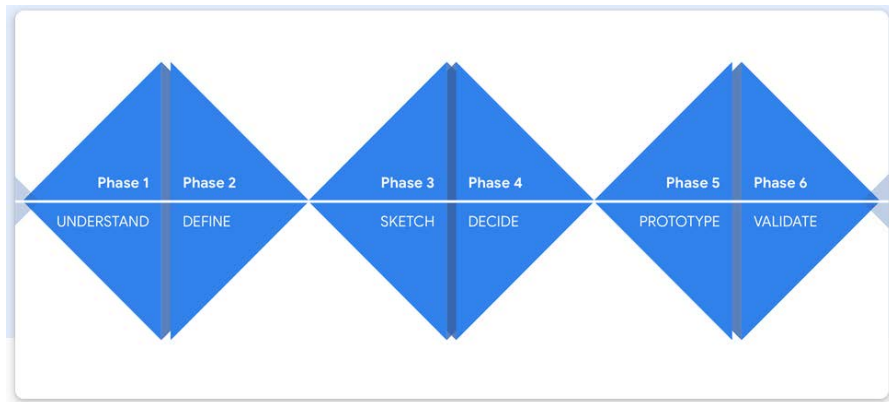


Figure 2: Six phases of Google's Design Sprint Methodology (designsprintkit.withgoogle.com/methodology/overview).

As the “How might we question” and the focus of the workshop were already predefined by Campusconnect, the Understand and Define phases were skipped. Teams started directly with Phase 3 Sketch using the Crazy 8 method. Participants were required to sketch eight ideas for the pre-defined “How might we” question in eight minutes. This generated 96 ideas in total. Figure 3 shows the exemplary result for one participant.

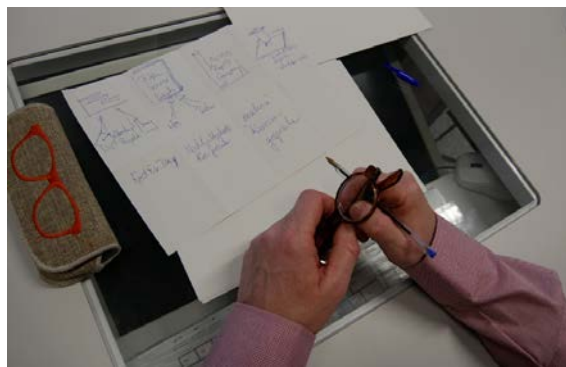


Figure 3: Example result of Crazy 8 method of one participant. Foto: private.

After that, every team member had four minutes to explain their ideas to the others, followed by a group discussion on how to cluster and expand ideas. In Phase 4 Design, all

team members got three votes each and selected their favorite ideas silently using post-its to attach to the preferred sketches (see Figure 4).



Figure 4: Voting on preferred ideas. Foto: private.

In Phase 5 Prototype, teams were asked to create one prototype for each of their three favorite ideas. It was briefly explained that prototypes should ideally be a press release, a role-play, a visualized use case, or an image, text, or other artifacts for this workshop. Teams distributed the work according to individual preferences and created their prototypes within one hour.

During Phase 6 Validate, teams presented their prototypes to the other groups and collected feedback. To follow a Stakeholder Review approach, especially students and company representatives were asked to give feedback. Feedback was collected digitally using a shared document. Figure 5 shows the presentation of one prototype and Figure 6 shows a snapshot of the feedback sheet.



Figure 5: Hop-on-hop-off bus tour prototype as social media post. Foto: private.

Hop on hop off bus tour	HMBS Lounge	Alumni Kanal	Unternehmenkennlernen Kurs	Partnerbörse
	Schwer aber seh	I like	I need	
i need		I like	I need	I wish. Bisher sch
I need	I wish	I like	I like	I need

Figure 6: Snapshot of Stakeholder feedback on prototypes.

Out of the nine presented prototypes, after feedback and discussion among participants, two were merged, which was a campus festival with the already existing sustainability festival. Instead of creating a second festival, it was agreed that to the existing sustainability festival taking place every year in June, startups with a sustainable business model should be invited to present themselves and win volunteers for their activities or interns/ working students for their ventures.

The other prototypes presented were a hop-on-hop-off bus tour for students to speed-visit eight different companies in one day, a seminar that consists of visiting different company events and reflecting on the benefits of it, shadowing of business leaders for one day, and discussion tables with selected companies every week in front of the canteen. Furthermore, a student lounge sponsored by industry partners was presented where students should get the chance to connect and network on campus in a nice and relaxing atmosphere.

As per digital solutions, one team presented a prototype for a social media-based alumni network and an exchange platform for connecting companies with university lecturers regarding guest lectures, excursions, and company visits. The planned guest lectures could then be opened for all students and displayed on digital screens next to the canteen, an idea brought in by another team that fitted nicely as an extension to the platform idea.

The workshop participants left inspired and energized, and the Campusconnect team elaborated on the feasibility of the eight prototypes and designed an interaction roadmap for the upcoming semesters after aligning the workshop results with the student ideas and the SCE brainstorming session.

New Formats for Interaction

Based on the results from the three different sources of idea generation for university-industry collaboration, the following new interaction formats will or have been implemented at HM's business school starting from the summer term of 2024:

- Shadowing of business leaders for one day or one-on-one meetings with individually chosen companies: already started, see Figure 7.
- Discussion tables with selected companies currently on a transformative journey every week in front of the canteen: already started, see Figure 8.
- Business Model Hackathon with four early-stage startups in MedTech and Robotics looking for co-founders with a business background on April 30.

- Inviting startups with a sustainable business model to the sustainability festival on June 18.
- Digital screen with information about guest lectures and interactive formats in the canteen.
- Student lounge area sponsored by industry partners: in progress.
- Social media-based alumni network: in progress.
- Offering a seminar consisting of company events and reflecting on the benefits of the events: planned to be introduced in winter term 2024/25.



Figure 7: Snapshot of the registration form for business leader shadowing or individual company meet-ups. Foto: private.



Figure 8: Discussion table with Deloitte on April 17. Foto: private.

Two ideas, however, had to be disregarded: the hop-on-hop-off bus tour, as it turned out to be difficult to organize for insurance-related reasons. And the VR glasses, as none of the industry partners currently has a VR experience in their office premises available which they could borrow the university.

Discussion and Conclusions

The described case study has a few limitations that must be considered when implementing the suggested student-company interaction formats. First, as the authors of this paper acted as a participant and a moderator of the workshop as well, a certain bias might have evolved regarding conclusions and what to make out of the workshop results. Regarding the selected participant sample for the co-creation workshop, it must be stated that only the ones who were interested in the topic participated in the workshop, which resulted in a sampling bias. Also, the student sample consisted only of females on the master level, while the professor sample included a male-dominated set of participants. Therefore, the workshop participant sample is not representative of the target population and the results might not be the first choice for all companies or students. However, due to the relative diversity of the workshop participant sample, the chosen ideas to pursue further were also very diverse. A professor- and industry-only sample for example would have never come up with the festival idea, which was driven by the students. On the other hand, the seminar will be offered as a joint product by professors and students and would never have been thrown in by industry and staff representatives.

Secondly, due to the qualitative approach and limited sample size of both the student feedback on existing formats as well as the co-creation workshop, the results are not generalizable. Another group of participants at HM or any other university would have come to different results. The same holds for the decision to use the Google Sprint methodology for the co-creation workshop. Though the authors learned that indeed most participants had gotten in touch with this methodology before and therefore questions regarding the “how to” were very few, in phase 6 feedback, the results of the gathered feedback on the initial prototypes were not very specific. Here, the workshop moderator should have explained in more detail what to expect, meaning explaining more in detail WHAT the participants liked or wished for with a certain prototype rather than IF they liked it. Other methodologies might have been a better fit in this regard.

Still, the case study has shown that Design Thinking is a suitable means also for universities to challenge the way they interact with industry partners and connect them with students. The results of the described co-creation workshop together with the results of the student projects and SCE collaboration, led to a vast agenda of new formats for the upcoming study terms, seven of them having emerged from the Design Thinking workshop. Equally valuable, however, were the contributions of the student teams with their fresh ideas and the brainstorming session with the entrepreneurship center on suitable formats tailored to business students. Jointly, these three ways of ideating new university-industry interaction formats worked very well for HM’s business school and have been a fresh start after the previous Lean Startup (Ries, 2020) build-measure-learn approach with incremental improvements only. The Campusconnect team is eager to pilot these new formats.

However, it cannot stop here. Consequent and frequent communication on social media channels will play a very important role in the success of new formats, as the questionnaire of career fair visitors revealed many had not seen any advertising and this finding is in line with Campusconnect's experience with other formats. Only if students receive information about events on their regularly used social media channels (LinkedIn and, more importantly, Instagram), will the message even get through to them in the huge amount of information they have to digest every day. In terms of a suitable time frame to apply upcoming rounds of iteration, the Campusconnect team will gather feedback after the first implementation of each new format to refine it. After three iterations, it will be decided whether to keep the format and iterate on an ongoing basis or to dismiss it and try new formats which will then yet have to be developed with involved stakeholders.

One topic is yet to be addressed, which is the question of how to prioritize more sustainable companies over others, a quest raised by two of the student teams (see chapter *Feedback from Students*). In the business school's aim to become more sustainable in several dimensions (campus, students and employees, curriculum, research, and transfer/ industry), it is paramount to strengthen collaboration with those companies who have an impact-driven business model as such or whose business practices are responsible. The next step therefore will be to develop a scoring model to select industry partners for student interaction formats based on how well they score on the defined sustainability criteria. The scoring model should follow a holistic approach for sustainability comprising economic, social, and environmental aspects (Baumast and Pape, 2022), or people, planet, and prosperity as aimed for in the United Nation's (2024) Sustainable Development Goals (SGS), which are applied and taught at HM, plus include governance topics. As there are 59 rating agencies in the EU (ESMEA, 2022) providing ratings for companies on Environmental, Social, and Governance topics (ESG), the idea is to start with a standard established ESG rating like MSCI Sustainable Impact (MSCI, 2024) or Morningstar's Sustainalytics framework (Sustainalytics, 2024) and design it in a self-answer way for the partner companies, tailored with additional HM-specific questions. Two research teams are currently working on such a self-evaluation tool. Once established, this will enable our students to meet, exchange with, and ultimately work for companies that make a positive impact.

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Investigating Gender Bias in Engineering Design Theory and Methodology

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ABSTRACT

While gender bias and its mechanisms and outcomes have been extensively documented and studied outside of the field of mechanical engineering, the field has not critically examined how gender norms and bias can negatively impact design practice. A consequence of not reconciling this blind spot within engineering design may result in the creation of more gender biased designs. We are developing a Design Implicit Association Test (IAT) to measure the extent of implicit gender bias. In this study, we present the development of gendered product associations for the Design IAT. Undergraduate mechanical engineering students ($N = 94$) took a survey in which they read two gendered Personas, (each of whom had similar levels of familiarity, skill, and aptitude towards technology, logic, and math) and were asked to rate everyday engineered products and items. We interpret our normed exemplar stimuli needed for the Design IAT and present next steps for this work in investigating the impact of gender norms on the engineering design process, particularly their impact on solution principles and long-term design trajectories.

Keywords: Implicit Association Test, Gender, Design Theory and Methodology

Introduction

Conceptual or mental models result from our human desire and need to find explanations and form more complex understandings of relationships between concepts or pieces of information within a given context (Johnson-Laird, 2004, 189-222; Norman, 2013). These models allow us to internalize the external world and are useful for a myriad of cognitive tasks that rely on accumulated knowledge. For example, problem solving, reasoning, and deductive reasoning are all sensitive to the quality of these representations (see Genter and Stevens, 2014 for a more extensive discussion). Within engineering design, mental models help designers predict the outcome of end-user behaviors and actions, understand their experiences, and anticipate circumstances they might encounter (Norman, 2013). Mental models encompass the knowledge, whether real or constructed, that is represented and accessible to our minds through the perceptions and experience of the individual.

To illustrate, imagine this story: you walk into a college-level mechanical engineering design classroom anywhere in the world. You might observe the instructor introducing the concept of fastening or joining of two materials. Before the instructor continues, they pose the following question to students: how might you mechanically hold two materials together? You notice the instructor neither shares the application nor the materials to be joined. Time magically stops for you to form a conceptual model for mechanically holding two materials together. After doing so, consider the following questions:

1. *Are people more likely to think about fastening through welding, screwing, nailing, riveting, or using nuts and bolts? Or,*
2. *Are people more likely to think about fastening through sewing, weaving, and knitting?*

Although both options are categorized as fastening methods, these two options represent distinct conceptual models (or, more specifically, functional approaches to fastening) within engineering design—with one being typically applied for rigid materials such as metals and the other for soft and flexible materials such as textiles. At issue is not whether design engineers are aware of diverse textile manufacturing methods. Rather, the issue pertains to the use of design exemplars which might shape readily-recalled mental models of fastening, i.e., the “fast” mental representations of what qualifies as fastening and what does not, consequently leading students to implicitly conceptualize fastening through the methods outlined in option one. Approach number one happens to be the most commonly taught approach to fastening in mechanical engineering design (Budynas, 2020).

While engineering design methods may appear systematic and objective, they reflect institutionalized patterns of knowledge and action that are responsible for creating the technology and systems that govern so much of our realities, capabilities, and possibilities (Costanza-Chock, 2020; Wizinsky, 2022). In their work, designers use various methods during the design process, but often do so implicitly (Wallace, 2011; Norman, 2013). One potential reason for this may be that designers are often following a prescribed development path, as the products they design are not always conceptually new. Even with dozens of design methods available, engineers often end up intentionally or unintentionally choosing design methods based upon the unique company or institution they are part of (Wallace, 2011; Chou, 2020). This biasing effect of knowledge is not new, and has been well recognized in several other contexts outside of design including reading, reasoning, and social perception (Klauer *et al.*, 2000; Calvo and Castillo, 2001; Maner *et al.*, 2005).

However, there are increasing efforts to approach engineering design through a design justice lens to prevent unintended harmful design outcomes—and with substantive impact (Costanza-Chock, 2020; Gallimore, 2021). For example, a 2022 study indicated that when design-for-justice principles were integrated into a community-engaged engineering project based in a rural village in the Philippines, designers’ mindsets

shifted to challenge dominant engineering ideologies that prioritize newness, performance, and technical features over sustainability and social change (Riley, 2008; Cech, 2013). Within this study, the design team was tasked to develop solar lanterns with an NGO (non-governmental organization); however, the team opted to alter the structure of the social system by resisting the NGO collaboration and instead helped local villagers start a business on their own terms (Reynante, 2022). This shows that there can be an impact when design-for-justice principles are integrated into the design engineering process.

While applying frameworks like design justice to the engineering design process may lead to more equitable outcomes, the fundamentals of engineering design have not changed in the past 50 years (Wallace, 2011). One example of this can be shown through the continued use of textbook examples of mechanical components and devices which have not been substantially updated in more than 60 years. In Fig. 1, the juxtaposed examples show the same cartoons for modes of failure of a bolted or riveted connection and a bench type press found in Shigley's first edition, *Machine Design* (published in 1956) and the most recent edition of the text, *Shigley's Mechanical Engineering Design* (published in 2020). A sewing machine shares similar components to a bench-type press and is arguably more familiar to students today. This leads us to pose the question: why wasn't a sewing machine featured in the 2020 edition instead of a bench type press?

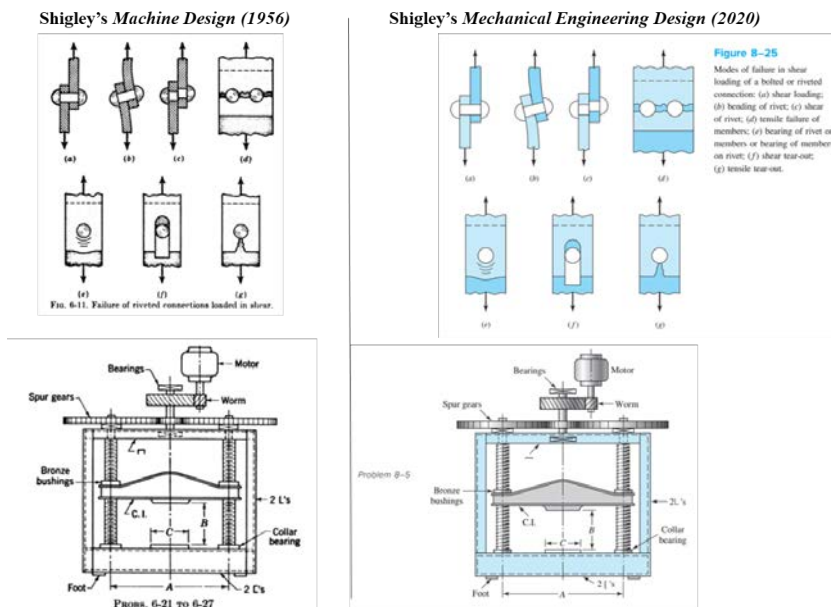


Figure 1: Textbook example comparison from Shigley's mechanical engineering design texts. Left-top: page 195 and left-bottom: page 218 (Shigley, 1956). Right-top: page 463 and right-bottom: page 472 (Budynas, 2020).

The lack of a broad set of examples that form the basis for conceptual models of "how to do things" in mechanical design can lead to implicit biases (Schauer *et al.*, 2023). If you have only ever been taught bolting and screwing as legitimate approaches to fastening

materials, it is possible to develop a bias toward these methods (Boysen and Vogel, 2009). By bias, we mean a systematic inclination to favor something over another—the absence of a neutral viewpoint in the situation (De Houwer, 2019). More problematically, unless you are trained specifically in user-centered design, modern mechanical design theories and methodologies do not account for implicit biases, like gender bias, within the theoretical frameworks. If you were asked to design something with women in mind as the intended user, it is likely that you will lean on your own conceptual models of feminine behaviors, attitudes, preferences, and cognitive styles when designing this product (Wallace, 2011; Ehrnberger *et al.*, 2012; Rommes, 2014; Criado-Perez, 2019). On top of this, numerous studies show that when products are designed without explicit attention to gender, they result in being gender specific and more directed towards men (MacKenzie and Wajcman, 1999; Rommes, 2014). Products in which specific attention is paid to be ‘gender sensitive’ often result in producing designs that run the risk of reinscribing traditional stereotypes of ‘women’ rather than challenging gender inequalities (Ehrnberger, Räsänen and Ilstedt, 2012). These products more often highlight *differences* between men and women, even though both needs and characteristics vary more between individuals than just gender (Hyde, 2005).

In this work, we hypothesize that the dominant technological imagination, or narrative that shapes design thinking, inherently constrains the engineering design process, and thus the design solution space. A negative consequence, if this hypothesis were true, would be the continuation of systematic biases toward designs that favor men over women, or, stated in another way, designs that are created for men rather than for women. This is not a new hypothesis, however. As Criado-Perez (2019) stated, when the default user is considered to be male and based on the male-experience, women and gender minorities who constitute half of the population—are seen as niche or invisible.

Despite decades-long documentation of gender-biased products and systems (Schiebinger, 2008; Moss, 2016), critical examination of gender bias in engineering design theory and methodology is often overlooked (Kang and Dong, 2023; Schauer *et al.*, 2023). Our contention is that since design thinking and design processes are intrinsically linked, we need explicit debiasing methods to address otherwise male-normed and -centric designs. Debiasing methods can advance the UN Sustainable Development goals for gender equality by equipping design engineers, most of whom do not have backgrounds in gender and feminist studies, with tools to find or avoid gender-bias issues in the engineering design process and methods (Esquivel and Sweetman, 2016). This work contributes to the field by addressing how gendered social norms and biases can negatively influence engineering design processes and outcomes (Kang and Dong, 2023).

This research investigates the causal effects of gender as an explanatory variable in the structures of solution principles in engineered products, and subsequently, their design outcomes. In our efforts to explore why designs remain resistant to debiasing, we are developing a Design Implicit Association Test (Design IAT or DIAT) to measure the extent to which biases systematically influence behaviors such as concept generation

and requirement setting. We theorize that implicit biases grounded in gender norms about products influence the behavior of designers in predictable ways. In the following sections, we introduce key theories and definitions that ground our research and study mechanisms. We then present the results from our survey, identify key learnings, and present a selection of our exemplar stimuli for the Design IAT. We conclude with next steps for developing a complete gender-bias Design IAT.

Theory and Background

Bias is known to influence the interpretation of information, decision-making, reasoning, and interpersonal relationships (Greenwald *et al.*, 1998). Although implicit bias is often perceived as an underlying influence within individuals that prompts them to engage in inappropriate or harmful behaviors, this perspective is inaccurate and limiting (De Houwer, 2019). There are several limitations when implicit bias is conceptualized as a latent mental construct. For example, Sukhera *et al.* (2018) observed that conceptualizing implicit bias as a stable entity that is difficult to change or control threatens people's core beliefs about who they think they are and aspire to be. Subsequently, awareness of one's implicit biases can lead to defensive reactions which hinder attempts to reduce harmful implicit bias in society (Howell *et al.*, 2015).

In this paper, we adopt the definition of implicit bias as *spontaneous and automatic evaluations that influence a variety of behavioral processes* (McConnell and Leibold, 2001; Oswald *et al.*, 2013). Defining implicit bias as a behavioral phenomenon rather than a mental structure expands its application, implications, and methods of measurement. Since individual behavior is often influenced by implicit group-based behavior, this position theorizes that individual behavior is reflective of the social group that person belongs to (De Houwer, 2019). Importantly, a behavioral perspective emphasizes that implicit bias is seen as something people (e.g., engineers, consumers) do rather than innately possess. Therefore, it is expected that "designers bring many presuppositions (the build-up of previous intra-actions) to the design situation, which manifest as historically and culturally specific assumptions and beliefs" (Balsamo, 2011, 23). In short, engineers have biases and blind spots because engineers are human.

To illustrate, in the early design stage specifically, the concept selection and evaluation stage, Toh *et al.* (2016) found that male student designers were biased *towards* their own ideas and female designers were biased *against* their own ideas, despite the quality or goodness of an idea. While both of these dynamics add subjectivity and inconsistency to the design process, male designers displayed more selection and ownership biases than female designers in the study (Toh *et al.*, 2016). This research highlights the complexity of biases, gender, and goodness of idea in a design setting indicating that these phenomena do not operate in isolation of one another but are inextricably intertwined (Toh *et al.*, 2016; Kang and Dong, 2023). Since gender norms and bias operate interdependently on both individual and systematic levels, we argue that we cannot reduce gender-biased outcomes, which systematically uphold gender inequality

(Nosek *et al.*, 2009), unless we address the underlying implicit gender biases within engineering design theory and methodology in and of itself.

To highlight this issue, we use gender as both the analytical and theoretical lens for this study. Specifically, we use gender value systems theory, which describes the power structure (norm) that organizes genders on a symbolic, structural, and individual level (Acker, 1990; Faulkner, 2000). In this theory, gender norms separate and divide people, behaviors, and tasks into the male-masculine and female-feminine domains where the default and superior being is the male norm (Acker, 1990). In other words, gender is akin to performance, significance, and value in society (Butler, 1999). We hypothesize that the implicit association of designs to masculinity or femininity systematically shifts the subconscious value individuals attach to a design. Simply put, if a design is associated with femininity, its value or worth is regarded as lower than when it is associated with masculinity. This shift in valuation leads to predictable behaviors in the specification of product characteristics (e.g., rate of heat transfer of a heat coil in a hair dryer vs. a heat gun). From this, we form our hypothesis.

H1: Participants will rate items that are associated with masculine functions in society *higher* than items that are associated with more feminine functions in society. In other words, there will be a difference in ratings between items that are functionally similar (e.g., these two items share similar functional models) but have different gender associations.

This paper is premised on our primary research question: *how do gender norms influence design thinking, engineering design theory, and methodology?* In this paper, we report on the development of stimuli for a Design IAT (DIAT). These stimuli evaluate the strength of gender associations of products. The following sections report on the development of these stimuli and the results.

Materials & Methods

From reviewing prior IAT literature, it is known that choosing and selecting stimulus for the IAT is non-trivial and remains a persistent concern around validity of the IAT, yet is often overlooked by researchers (Phipps and Hamilton, 2023). To mitigate this oversight, we normed our stimuli through current mechanical engineering design students at a large public, research institution since they are likely the next generation of engineers who will develop the technologies and systems in our world. In this process, we were able to down-select exemplar stimulus accounting for their relation to the target concept and familiarity in common English language, society and culture, and engineering. In the following subsections, we describe the details of the procedure, participants, and study materials used to generate and select the target stimuli (e.g. engineered products) needed to develop our design IAT.

Procedure. We used a Qualtrics survey to gather the study data. The study was approved by the university Institutional Review Board. After agreeing and completing the consent form, participants proceeded to the demographic portion of the survey. This

section asked participants to report basic demographics in addition to class standing and design experience. After completing this section, participants then read two personas: *Tim* and *Abby*, both of whom were based on existing materials used to explore gender biases in software engineering (Burnett *et al.*, 2016). Participants then proceeded to a series of rating tasks of stimuli (e.g. common engineered objects and products) on a scale of 1 to 10, where 1 represented an object *Abby* was likely to use or own and 10, represented an object *Tim* was likely to use or own. Participants were encouraged to rate as quickly as they could. The development of these stimuli is further discussed in Study Material Development.

For the study, participants were recruited from two upper-division undergraduate mechanical engineering design classes at a large, public research institution in the Pacific Northwest. Participants in these courses were first introduced to the survey in-class, with time to ask questions, and through a course-wide email with a link to the survey. The survey was voluntary, and no incentives were offered. We purposefully recruited from these two required design courses because they provide project-based design and prototyping experiences through a well-organized engineering design process which includes planning, problem definition, concept ideation and various levels of product realization, machine design, testing, and failure analysis.

Participants. *N*=94 participants completed the survey. When asked to evaluate their design experience on a 7-point scale which ranged from ‘1-no design experience’ to ‘7-expert in industry or academia’, 84% of participants (79) reported having some or considerable engineering design experience (scores > 3), therefore we can view participants in this study as people who are familiar with the design engineering process in university and or industry environments. 14 identified as newer to engineering design, with little or no experience (scores < 3).

When participants were asked to self-report on academic year, age, and racial and ethnic identities we found that 90 participants were fifth or fourth-year undergraduates in mechanical engineering and the median participant age was 21 years old, with a range of 21 to 37 years. 81 participants (86%) identified as men, 11 (11.7%) as women, 4 (2.3%) as non-binary, gender non-conforming, or transgender. When asked to report race and ethnicity, 69 participants (73%) were white, 7 were Hispanic or Latino, 4 were Asian, Native Hawaiian or Pacific Islander, 2 were Middle Eastern or North African, 1 was Black or African American, 12 participants identified as multiracial.

Study Material Development

Persona Development. We created two personas, *Tim* and *Abby*, using the GenderMag Method (gendermag.org), which is a process and set of materials developed by Burnett *et al.* (2016) aimed at identifying gender-inclusiveness issues within software development. GenderMag Method’s customizable persona foundations are derived from qualitative and quantitative research in gender studies and highlight up to five facets of gender differences: motivation, information processing style, computer self-efficacy, risk

aversion, and tinkering (Burnett *et al.*, 2016). In sum, *Tim* and *Abby* are statistical representations of facet values *most frequently* seen in how men and women view and use technology, respectfully. Since personas are “archetypes” of user groups, they are at risk for gender stereotyping (Adlin and Pruitt, 2010). In attempt to ameliorate this, GenderMag personas are constructed such that *Tim* and *Abby* both have equivalent math and logic skills, domain knowledge, and skill with the technology that they use regularly (Burnett *et al.*, 2016). To avoid nearly identical personas, except for persona facets, we crafted *Tim* and *Abby* personas with different jobs and hobbies. However, since *Tim* and *Abby* are both equally competent individuals with technology, having participants rate common engineered objects based on whether *Tim* or *Abby* would most likely use the presented object allowed us to observe how participants associated gender through the ratings of these products. Like the GenderMag Method, developing the gender-bias Design IAT (DIAT) aims to first understand gender biases within engineering design, and then help develop practical ways to move towards gender inclusiveness in design theory and methodology.

Generating Exemplar Stimuli for the Design IAT. We applied gender value systems theory (from Theory and Background) to generate stimuli anchored in the male-masculine and female-feminine domains to observe how participants implicitly associate functionally similar designs with masculinity (i.e., the work-public-industrial sphere) or femininity (i.e., the home-private-domestic sphere). Studies show that gender norms manifest through design such that masculine-associated design aesthetics signal performance and value in society, regardless of actual functionality and performance (Acker, 1990; Faulkner, 2000; Ehrnberger, Räsänen and Ilstedt, 2012). We generated 28 pairs of stimuli that are functionally similar, except in appearance or use-case, and exist in the home-domestic or work-industrial spheres. For example, one stimuli pairing was the *hair dryer* and the *heat gun*. Both products are functionally similar and are constructed with a motor-driven fan that blows ambient temperature air over an electrically heated filament. However, the *hair dryer* is often conceptualized to exist in the home-domestic sphere and *heat gun* is often conceptualized to exist in the work-industrial setting. Table 1 lists a select number of paired and gendered stimuli. We included an additional 15 unpaired engineered products to test thresholds of stimuli familiarity. In total, participants rated 71 exemplar stimuli. Within the survey, presentation of individual words was randomized, and thus any pairings were not made explicit to participants.

Table 1: Selection of paired stimuli that are functionally similar but exist in masculine and feminine domains.

Work-Masculine	Home-Feminine
Handheld drill	Handheld blender
Heat gun	Hair dryer
3D Printer	Sewing Machine
Briefcase	Purse
Soldering iron	Hot glue gun

Results & Discussion

As presented in the introductory sections, we hypothesize that barriers to reducing gender-biased design outcomes remain due to theoretical and methodological gaps in understanding how gender norms shape design thinking, theory, and methodology. This paper presents (1) how we used gender and implicit social cognition theory to norm exemplar stimuli for a gender-bias Design IAT and (2) key findings from our data and our selected exemplar stimuli. While these findings should not be broadly generalized, these findings reveal insight into implicit biases about product function and value that may align in certain ways with gender value system theory (H1).

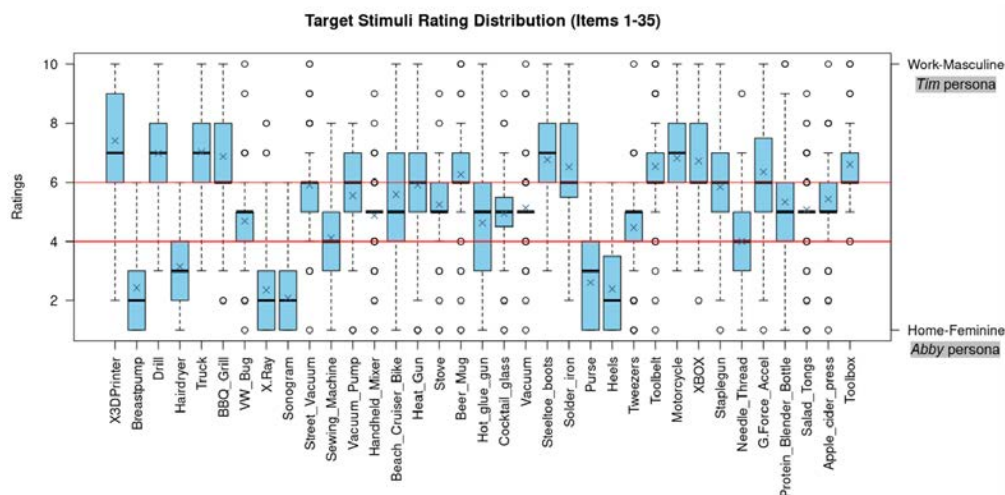


Figure 2: Target stimuli rating distribution

Stimuli Rating Distribution Findings. First, for every term, a median and average rating, range, and outliers was calculated across participants. These ratings, as they were presented in the survey, are visible in the boxplots presented in Fig. 2 and 3. Higher ratings indicate items as more consistent with the masculine *Tim* persona, whereas lower ratings are reflective of more close alignment with the feminine *Abby* persona. As is visible in Fig. 2 and 3, there were several items that aligned most exclusively with each persona, for example, *3D-Printer*, *Drill*, or *Truck* were rated as more masculine, whereas items like *Breast pump*, *Hairdryer*, or *Purse* were rated as more feminine. Additionally, there were several items that appeared equally likely to be associated with both personas, which are items in between the horizontal red lines at Ratings equal to 4 and 6. Some of these items like *Paintbrush*, *Clothes Iron*, and *Pasta Machine* could be seen as functional in both the work (masculine-coded) and domestic (feminine-coded) domains.

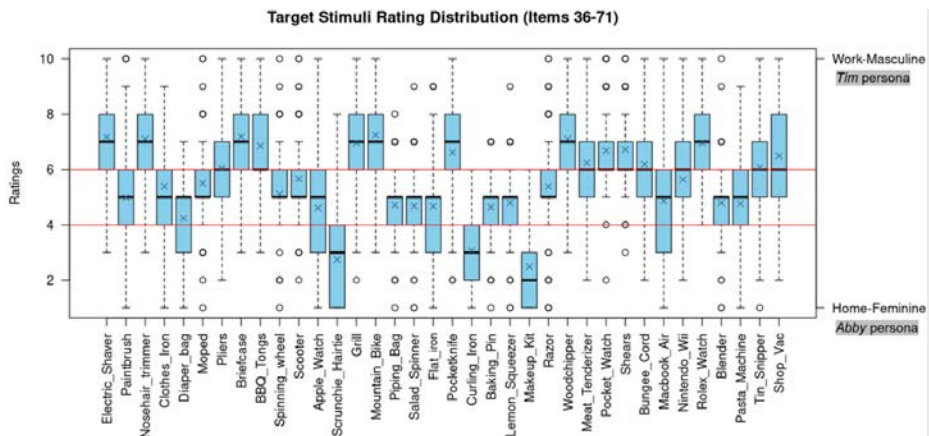


Figure 3: Target stimuli rating distribution continued

Relative to H1, we conducted comparisons for the 28 pairs of gendered items (see Fig. 4). A paired t-test was run to compare the mean differences between functionally similar products situated in what is typically considered 'Work-Masculine' and 'Home-Feminine' domains. The data showed very strong evidence that the mean stimuli ratings for the masculine-coded products were *higher* than mean stimuli ratings for the feminine-coded products ($p=2.24e-07$, two-sample, one-sided t-test), with a mean difference of 2.026. These results support our hypothesis and study objective. People's gender associations with products may correlate with a product's perceived association with stereotypically masculine or feminine behavior, functions, and tasks in society. This phenomenon occurred even when participants were presented with two technically competent, but gendered personas *Tim* and *Abby*. While this was our study objective, these results signal which gendered-associated stimuli we can use for our gender-bias design IAT.

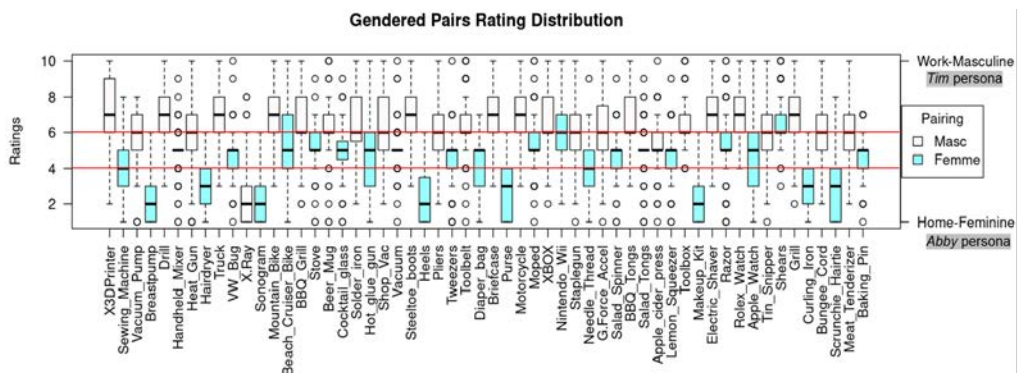


Figure 4: Rating distribution of gendered pairs as distinguished by Masc-Femme colored pairings

Persona Reading Time Discrepancy. In an attempt to ensure that all participants read the included personas, a simple analysis was conducted to compare average reading time for the *Tim* and *Abby* personas. Results indicated that *Tim* was read significantly longer than *Abby* (9 minutes vs 2.1 minutes). This finding is somewhat

quizzical as the personas themselves were nearly equivalent in length (439 words vs 432 words) and structure. However, despite this significant difference in reading time and apparent longer reading of the *Tim* profile, it must be mentioned that it does not appear that participants ignored the *Abby* profile, as the average reading time (238 words per minute) is consistent with the reading of a passage of this length (Brysbaert, 2019).

Excluding gender as an independent variable. We did not report results using gender as an independent variable for two reasons: (1) participant demographics closely reflected diversity within mechanical engineering in the U.S, i.e., 80 % white, 90% male-dominated (U.S Bureau of Labor Statistics, 2024), and because this is the socially dominant group in the field, we wanted to norm our stimuli through this group; (2) we hypothesize that implicit gender biases are socially constructed and therefore systemic and largely representative of the conceptual models and behaviors upheld by dominant social groups in design engineering, rather than being innate to the individual (Nosek *et al.*, 2009; Rommes, 2014; De Houwer, 2019).

The purpose of the norming test was to down-select which gendered stimuli will be best for our Design IAT. Our candidates for masculine exemplar stimuli include *Briefcase*, *Steel-toe boots*, *3D Printer*, *Handheld Power Drill*, *Truck*, *Motorcycle*, *Mountain Bike*, *Grill*, *Rolex Watch*, *Pocketknife*, *Woodchipper*, and *Electric Shaver*. Candidates for feminine exemplar stimuli include *Purse*, *Heels*, *Breast Pump*, *Hair Dryer*, *X-Ray Machine*, *Sonogram*, *Makeup Kit*, *Curling Iron*, and *Hair-tie*.

Limitations & Future Work

This study has several strengths. First, rather than merely asking participants to rate a given product as ‘masculine’ or not, participants were given an explicit anchor of gender norms, using validated personas from the GenderMag framework (Burnett *et al.*, 2016). Thus, we argue that the provided ratings provide a more reliable and consistent rating of gender associations that are less explicitly tied to individuals’ own experiences with said object. We argue that this provides a more robust data-informed stimulus set that can then be used to develop a design IAT. As all participants rated all terms at a single time, this also ensures that should there be any inherent bias in a given individual, this would be consistent across all rated items. Further, participants in this initial study are all engineering students at a large public land-grant university enrolled in design coursework, which likely reflects some consistency with professionals working and interested in the field of design.

However, this study is not without limitations. First, participants may not have recognized several items during the rating task due to unfamiliarity or ambiguity (i.e. *beach cruiser bicycle*, *piping bag*, and *flat iron*). This could have created confusion when rating items that *Tim* or *Abby* would be more likely to use and contributed to the non-discriminate ratings we observed. Lastly, *Tim*’s persona appeared first in the survey, with *Abby*’s persona second. The observed significant time discrepancy could allude to the

fact that participants spent more time reading Tim's persona rather than Abby's. In the follow-on study, the persona order will be randomized.

Further research includes completing our gender-bias Design Implicit Association Test (DIAT) using the selected exemplar stimulus from this study. Our next study will include distributing the DIAT to investigate the causal effect of gender as an explanatory variable in the structures of solution principles in engineered products (Kang and Dong, 2023). In addition, longitudinal studies could provide insight into how students change their thinking when exposed to engineering design theories and methods that explicitly account for the influence of gender norms in product development.

Conclusion

Our broader research aim is to investigate how social norms, like gender, seep into engineering design theory and methodology and thus shape design engineers' implicit biases and behaviors in predictable and systematic ways (Nosek *et al.*, 2009). The conceptual models mechanical engineers learn in the engineering design process for product development can entail gender bias if, for example, students lack exposure to examples of products for women or gender research. To fill this gap in engineering design literature, we incorporated theories from gender studies, engineering design, and implicit social cognition research to begin developing a gender-bias Design Implicit Association Test (DIAT), which will measure the extent to which biases can systematically influence behaviors such as concept generation, need finding, and requirement setting. This work is in pursuit of advancing gender equality and UN Sustainable Development Goals (Leach, 2016) through bridging the gap between engineering design theory and real-world consequences of gendered perceptions on creativity and design, engineering aptitude, methods, and product form and function.

In sum, we used our stimuli norming survey, built with GenderMag Method validated personas, to select which exemplar stimuli embody gender association and should be used in our follow-up Design IAT. We hypothesize that the gendered technological imagination, in which the default (or implicit) user is considered male and based on the male-experience, may systematically reinforce implicit gender bias and inequality through the design engineering methods and processes that are taught in university (Salehi *et al.*, 2019). To ensure that design processes and practices contribute to a more sustainable and gender equitable future, we argue that it is important to equip ordinary design practitioners, who may not have backgrounds in user-centered design or gender and feminist studies, with tools to identify gender-inclusiveness issues in design, understand why the issues matter, and then know what to do to create persistent change.

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Bamboo Houses in Bali: Evaluating Locals' Perception to Promote Sustainable Construction Materials

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ABSTRACT

This paper examines the perception of bamboo as a construction material among Balinese people. Despite bamboo's promise as a sustainable, locally sourced material, there is a gap in understanding its acceptability for housing construction. This research aims to bridge this gap through a user-centered approach, emphasizing the importance of incorporating the perspectives and preferences of local populations in architectural decision-making.

The paper is structured as a multi-method investigation. After a brief literature review to contextualize bamboo's qualities and limitations in housing design, the fieldwork conducted in Bali, Indonesia, seeks to understand the current perception of bamboo as a housing construction material by the local habitants. The study includes a survey (57 participants), three in-depth interviews with bamboo experts, and four potential users undergoing an interview *a priori*, a commentated walk, in bamboo buildings, and interviews *a posteriori*. The results of the study are presented through various qualitative indicators which provide a comprehensive understanding of how bamboo is viewed and whether it is considered suitable for housing in Bali.

This research contributes to the field by employing a multimethod approach, highlighting the importance of a user-centered perspective in architectural design. The study reveals that having an embodied experience of a place can modify one's perception of a material. It argues for the relevance of design theory in promoting sustainability, showing how it can lead to more informed and effective policy and architectural decisions.

Keywords: Bamboo housing, Qualitative indicator of perception, Acceptability of a material, Commentated walks.

Introduction

The buildings sector plays a crucial role in decarbonizing the global economy, and the International Energy Agency (IEA, 2022) highlights that buildings contribute significantly to energy consumption and carbon emissions in the Association of Southeast Asian Nations (ASEAN) region. To achieve a substantial reduction in the carbon footprint of buildings, the transition towards affordable low-carbon and bio-based construction materials is essential. Bamboo, a sustainable and locally available

material, holds great promise in this regard (Lam, 1996; Sujarwo, 2018). The latest International Energy Agency report emphasizes the importance of increasing the recognition and adoption of such materials (IEA, 2022).

By opting for sustainable materials, locally grown and transformed, we can take a step towards mitigating the issues of the construction sector in terms of environmental issues (IEA, 2022) and social justice as bamboo plays an important role in the local economy (Arinasa and Bagus, 2010).

In Indonesia, bamboo has historically been used for various purposes, including as a building material for houses (Sesotyaningtyas *et al.*, 2017; Sujarwo, 2018; Wibowo, 2020). However, the perception of bamboo in housing design among the local population still needs exploration. A study conducted in Southwest Bali revealed that bamboo is no longer widely used for houses (Sesotyaningtyas *et al.*, 2017). Another recent study on a residential area in Jakarta concluded that is not widely applied in home design (Nurdiani, 2020).

Bali's contemporary bamboo buildings captivate tourists, evoking deep and varied emotional experiences (Sofian *et al.*, 2017). However, locals' perception of bamboo as a construction material remains unclear (Lam, 1996). While contemporary bamboo structures enthrall visitors, some perceive bamboo as inferior to "conventional" materials, such as cement and bricks (Omuh *et al.*, 2019). This paper aims to bridge this dissonance by exploring local populations' perceptions of bamboo homes.

Context and Focus

This work questions the acceptability of bamboo as a construction material for housing as perceived by native Balinese people. Although bamboo possesses the potential to address sustainability and economic development issues, there remains a need to promote awareness and appreciation of its benefits (Habibi, 2019).

Bamboo

Bambusoideae culms, which can grow up to 25 meter in six months in tropical regions (Broto *et al.*, 2014), only take three to five years to mature to full strength (Trujillo, 2007). Bamboo Petung (Kaminski *et al.*, 2016) is the most commonly used for bamboo construction in Bali. These bamboo poles can last at least 30 years in external settings above ground without undergoing much transformation apart from being dried, drilled, cleaned and treated against termites' attacks, often by soaking in a solution containing boric salts (Kaminski *et al.*, 2016b). The leaves can also be used to make "Alang-alang" roof coverings. Based on recent research conducted on mechanical properties of bamboo (Kaminski *et al.*, 2016c), there is no doubt that bamboo is structurally suitable for small housing buildings.

Although bamboo has a lower embodied energy compared to concrete or steel (Dongwei, Hongwei & Yingjun, 2011), it still struggles to compete against these materials in the construction industry. This is the case even in regions where concrete and brick are not

produced locally and must be imported, indicating a reluctance in the construction sector to shift towards more eco-friendly alternatives like bamboo (Fitrianto, 2015). Moreover, bamboo seems to carry a negative stigma, particularly among local communities, where it is perceived as a material for the economically disadvantaged, transient, and of inferior quality (Nurdiah, 2016). Waddress bamboo as a structural material, using full-culm bamboo. Bamboo is a sustainable material, locally grown, treated, and manufactured.

Based on this literature, we assume that bamboo is suitable and relevant for housing construction in Bali. Moreover, it is currently a place where there is a high concentration of bamboo craftsmanship and bamboo factories. The material is locally available (Arinasa and Widjaja, 2005), and a couple of emblematic buildings are located on the island (Sofian et al., 2017).

Perception and Acceptability

This paper aims to assess how the Balinese population perceives bamboo construction, with a specific focus on bamboo housing and its potential for acceptance. To achieve this, it delineates qualitative indicators that could serve as guidelines. Each indicator should reveal a facet of how is perceived as a construction material and whether bamboo houses are regarded as appropriate by the people of Bali.

We understand indicator as either a qualitative or quantitative element that serves as a straightforward and reliable tool for tracking changes associated with an intervention. In this case, we focus on qualitative indicators to focus on opinions and perceptions. The goal is to examine each of these indicators to determine what factors may either promote or deter individuals from selecting bamboo as a building material for their homes.

This research examines the a priori acceptability of materials, particularly focusing on perceptions before direct embodied experience. Acceptability involves subjective aspects such as perceived utility, usability, expected social influences, attitudes, and norms, playing a crucial role in material choice (Terrade et al., 2009). Once exposed to bamboo structures, an individual's acceptance is also shaped by practical utility and usability (Terrade et al., 2009).

Perception, a subjective representation, is integral to acceptability. Kim (2015) emphasizes the need to explore factors like age and background that influence technology acceptance. We define a priori perception as the pre-experience mental image of an object, contrasting with in situ or spatial perception through embodied experience, which involves interpretation (Gibson, 1976; Gonzalez, 2014) and is influenced by observer characteristics and socio-cultural context (Adolphe, 1998).

Spatial perception combines objective elements (sound level, luminosity, geometry) with subjective aspects (observer sensitivity, socio-cultural context) (Gonzalez, 2014). It's a synthesis of multiple perceptions at a given moment (Adolphe, 1998), encompassing light, colors, smells, and sounds, and is influenced by cultural context and background.

Focusing on bamboo construction, factors like lifespan, cost, structural strength (perceived safety), and sustainability are pivotal. Local availability of bamboo is also critical, considering the environmental impact of transport (Kaminski, Lawrence & Trujillo, 2016a).

These various literature findings allow us to draft the following list of perception indicators:

- Sociocultural context;
- Cost perception of bamboo construction;
- Perceived lifespan of bamboo construction;
- Perceived safety of bamboo structures;
- Perceived sustainability of bamboo houses;
- Local bamboo availability;
- Sensory perceptions in a bamboo space.

Additional indicators from bamboo construction users and stakeholders are included.

Methodology

This section establishes the methods to test and complete these indicators. The selected methods are the survey, the in-depth interview, and the commented walk. This multimethod research strategy provides a comprehensive understanding of the subject. This methodological diversity can serve as a model for other design research, showcasing how different approaches can be integrated to gain a broader view of a design problem.

Survey

The first one, the 24-question survey, aims at a large public and got 57 participants. It collects data on the common materials used in Bali, the ideal material participants would choose for a new building, and then evaluates the perception of bamboo from various angles. The survey is an online form, available in English or Bahasa Indonesia (translated with the help of a native speaker), which was advertised in local snack restaurants, coffee places and streets through posters. A printed version of the questionnaire was printed and filled out by passerby in cities and villages all around Bali.

Interview of bamboo experts

The second method, the in-depth interview (Beaud, 1996; Savoie-Zajc, 2007), first targets three expert actors in bamboo construction: a bamboo structural engineer, a bamboo architect, and a self-built bamboo house owner. Each one of them brings an overview of their domain regarding bamboo. Being practitioners in the field, they have an overview based on their experience of the pros and cons of the use of bamboo but also of how their clients react to bamboo.

The findings are also enriched by another bamboo expert's opinion: Elora Hardy, designer at IBUKU, agreed that we include one of her speeches in the present study. Thus, her perspective broadens the results.

Interviews and Commentated walks with potential users

This study delves into the local Balinese community's perceptions and preferences towards bamboo as a construction material, further engaging with potential bamboo house occupants through additional interviews.

Initially, a set of interviews is conducted with four individuals selected from survey respondents. In the initial phase of the process, interviewees are not presented with any physical representations or constructed forms of bamboo houses (Di Méo, 1990). Thus, their impressions are solely based on the mental image they hold, which remains invisible to the researcher. This approach aims to capture the participants' intrinsic perceptions, influenced by cultural background, personal experiences, and current mindset. Our primary focus is on these initial, *a priori* perceptions.

To deepen the investigation, a method known as photo elicitation, detailed in Pretto's (2015) research, is employed. This technique introduces visual stimuli during or after the initial phase of the interview to explore material perceptions further. Participants either select an image beforehand to bring to the session or are presented with a series of bamboo construction photos by the researcher, from which they choose at least three for discussion. Incorporating photographs of the participants' own homes is also encouraged to facilitate a more comfortable discussion environment by relating to familiar materials.

Subsequently, the participants partake in a commentated walk, an ethnological method aimed at capturing on-site sensory feedback (Thibaud, 1998; Thibaud, 2001). This technique serves to gather sensory perception indicators directly from the participants.

Participants are initially introduced to a compact, 9-square-meter annex traditionally used for storage, constructed with a bamboo framework and with adobe for wall infill. They are tasked with envisioning a fictive scenario that repurposes this building for their personal use and comment the space. Participants are then accompanied to a bamboo house featuring a comprehensive layout that includes a kitchen and living area, a guest restroom, a bedroom suite that opens into a covered outdoor bathroom, and a mezzanine/attic space designated for storage and occasional guest accommodation.

During these guided exploratory sessions, an unforeseen element disrupts the intended protocol: the property owner, despite prior agreements for absence during the tours, is present due to unforeseen circumstances. This deviation, although potentially influencing the participants' critiques, eventually facilitates enriching interactions between the curious participants and the owner, answering various inquiries.

Following this on-site exploration, *a posteriori* interviews are reconvened to assess the participants' perceptions after their visit, providing insights into the post-experience viewpoint (Forget, 2013) of bamboo as a building material.

Data processing

The analysis the data serves dual purposes: firstly, to understand user perceptions of bamboo habitats and to identify the indicators underpinning their opinions, first broadly through the survey, then with more depth and nuance through the interviews and commentated walks.

Transcription of the in-depth interviews aims for utmost fidelity to the original audio, including non-verbal cues, as these elements are crucial for a comprehensive sociological analysis (Beaud, 1996). Key discussion points will be underscored to derive specific indicators or highlight insights that encapsulate core opinions expressed during the interviews.

For interviews with potential bamboo house occupants, the goal is to extract comments reflecting qualitative indicators that shape their views on bamboo as a viable construction material for habitation. Each participant's profile is synthesized to reflect their unique perspective on bamboo housing.

The analysis of commentated walks aims to reveal users' interactions with bamboo structures in physical rather than purely conceptual terms, transitioning from ideational preconceptions to tangible observations. Initial data processing involves transcribing comments from these walks, focusing on articulated spatial perceptions and the frequency of specific descriptors to interpret common themes or sentiments (Thibaud, 2001). This method identifies a "community of perception" through recurring observations across different participants (Gonzalez, 2014).

The post-walk interviews compare pre- and post-visit perceptions, enriching the understanding of each interviewee's stance towards bamboo as a construction material. This comprehensive approach yields a set of user-defined criteria for evaluating bamboo spaces, albeit non-exhaustive and contextually bound to the study's scope. These insights, alongside survey and interview data, establish a foundation for qualitative indicators pertinent to bamboo housing.

Findings and discussion

Survey

In a survey of 57 respondents, primarily Indonesians, participants were queried about construction materials of their choice for housing, focusing on preferences between bricks, concrete, wood, and bamboo. The survey revealed a predominant preference for bricks, with 46 participants (85%) favoring it for their ideal construction prior to being asked about any particular material (Figure 2). Despite initial reservations, 51% expressed interest in bamboo for new extensions when asked specifically if they would consider bamboo as a desirable option, highlighting a gap between initial material consideration and subsequent preference shifts.

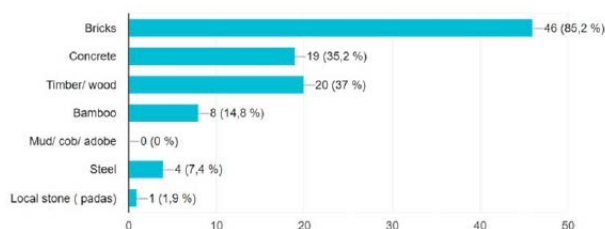


Figure 2 – the percentage of people selecting materials for their ideal new building

The analysis sought to understand material standards and preferences, revealing bricks, concrete, and wood as dominant choices, with bamboo often overlooked initially yet considered favorably upon further reflection.

The survey also explored demographic influences on material preference, finding no significant correlation between participants' age or originating district and their acceptance of bamboo construction.

Participants' perceptions of bamboo's cost were also examined (Figure 3), with the majority viewing it as cheap or affordable, yet occupation played a role in nuanced perceptions of affordability.

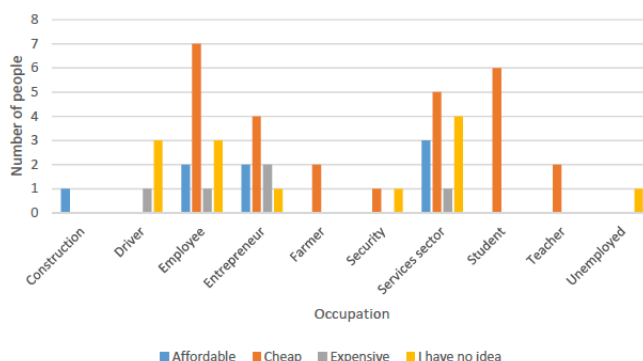


Figure 3 - perception of the cost of bamboo construction as a function of the occupation of the participants. The lifespan of bamboo construction was also questioned. Only two respondents believed bamboo could exceed this duration, highlighting concerns on bamboo's longevity. A striking 33% percent of participants perceived bamboo building as holding up less than 5 years. The study explored whether familiarity with bamboo house owners affects perceptions of bamboo's durability. Results indicate that those without personal connections to bamboo house owners tend to view bamboo as having a shorter lifespan. Conversely, individuals acquainted with bamboo house owners are more likely to perceive bamboo as having a longer durability, up to 25 years.

The analysis of open-ended responses provided qualitative insights into perceptions of bamboo housing, utilizing keyword occurrences as indicators. Participants responded to questions about their immediate associations with bamboo houses, conditions under

which they would consider bamboo for construction, and their views on the pros and cons of bamboo construction.

The ambivalence towards descriptors like "cheap," "classic," "simple," and "traditional" suggests mixed perceptions of bamboo's value and aesthetic appeal. Concerns were raised about maintenance, along with fears of bamboo being short-lived, weak, susceptible to termites, flammable, and generally unsuitable for housing.

Conversely, positive sentiments associated bamboo with uniqueness, natural beauty, sustainability, and artistic qualities, emphasizing its local abundance, eco-friendliness, earthquake resistance, and comfort. These findings reveal a complex landscape of perceptions towards bamboo housing, with significant appreciation for its aesthetic and environmental benefits tempered by practical concerns regarding its durability and maintenance.

Interviews of bamboo experts

The section consolidates insights from three perspectives on bamboo construction: an architect (Chiko), a structural engineer (Thierry), and a bamboo house owner (Ketut), complemented by comments from a conference by Elora Hardy, a leader in bamboo design.

Architect's Perspective: Chiko, with extensive experience in bamboo architecture, emphasizes the material's sustainability and creative potential. Despite his professional focus, he admits his own home doesn't utilize bamboo due to its design predating his bamboo advocacy, highlighting a personal and professional dichotomy.

Chiko reflects on changing perceptions, noting that bamboo was once considered a "poor-man's material" but now, with international influence, "the Europeans and Americans are using bamboo now, then it becomes fancy."

Chiko highlights the challenges and possibilities of bamboo, advocating for improved treatment methods to enhance its durability and its use in disaster-relief housing solutions. However, he draws attention to the challenges with bamboo's durability and urban integration.

Engineer's Perspective: Thierry, an engineer who relocated to Bali, was drawn to bamboo construction for its ethical and environmental credentials. He observes a persistent cultural resistance in Bali, where bamboo is stereotypically viewed by locals as inferior, but insists on its potential for longevity "if it is well designed and built." His strategy to change minds involves showcasing bamboo's capabilities through "large, impressive buildings", for instance within the luxury tourism sector, and offering maintenance services to demonstrate its durability.

Homeowner's Perspective: Ketut, a self-constructed bamboo house owner, represents a local embrace of bamboo's affordability and aesthetic appeal, despite rising costs due to commercialization. His experience highlights bamboo's practical benefits and challenges, including issues with pest infestation due to inadequate treatment.

His narrative reflects a broader issue of bamboo's perception and utilization in Bali, where it's considered "old news" and primarily a business opportunity rather than a viable construction material for locals. He laments the shift away from bamboo, noting its renewable advantage over traditional materials: "for a tree to fully grow and be used for beams, you have to wait a hundred years, whilst with bamboo, in 7 years, it is done."

His story underscores a generational and cultural shift in material preference, from traditional to modern construction materials.

Designer's Perspective: Elora Hardy details the innovative, aesthetic, and sensory appeal of bamboo construction, stressing the importance of treating bamboo to overcome its natural vulnerabilities. Hardy's approach integrates bamboo's organic form with the landscape, emphasizing sustainability and the need for renewable construction materials.

She addresses misconceptions and the material's historical vulnerability to pests, asserting that "it was almost impossible to reliably protect it from insects" until recent advancements, which should now be advertized more. Hardy discusses bamboo's luxury positioning and cost implications, underscoring the complexity of its treatment and preparation process: "the raw material is very affordable. But it has to go through so many hands... that by the end of it, our clients have embraced it as a luxury product."

She confronts the stereotype of bamboo as an inferior material and discusses the regulatory and cost challenges of promoting bamboo as an environmentally friendly option.

Interviews and Commentated walks with potential users

This section profiles participants Ayu, Ade, Devi, and Ngurah, detailing their experiences and perceptions regarding bamboo.

Ayu, a 30-year-old accountant from Gianyar, emphasizes durability and tradition in her material choices, favoring concrete and wood while recognizing bamboo's environmental and cost benefits despite its perceived shorter lifespan. She values bamboo and brick for their aesthetic appeal, especially along-alang roofing. Ayu prefers natural, well-lit spaces, as demonstrated through photo elicitation. Her perspective on bamboo shifts positively after the commentated walk, seeing its potential despite durability and maintenance reservations.

Ade, a 21-year-old English literature student, views bamboo as traditional and less suitable for urban life at first. The commentated walks challenges her initial skepticism, showcasing bamboo's aesthetic and environmental merits, and influencing her to consider it for future living spaces. She highlights the material's comfort and natural aesthetic. Living in a home that combines modern and traditional materials, she encounters issues like mold but starts appreciating bamboo's strength and visual appeal, imagining its use in rural homes rather than in urban settings.

Devi, a 22-year-old hospitality employee, initially sees bamboo as luxurious but not practical for her own use, concerned about its durability. After visiting bamboo constructions, her stance evolves, appreciating bamboo's ability to create inviting, relaxing environments. This visit helps her overcome durability concerns, making her more open to considering bamboo for future construction endeavors.

Ngurah, a 65-year-old retiree, prefers traditional materials like brick and concrete for their ease of maintenance and durability, yet he acknowledges bamboo's health and environmental positives. Although he appreciates bamboo's aesthetic and environmental benefits, his practical concerns about its longevity and maintenance cost keep him from fully embracing it for personal use. However, his interaction with bamboo structures provides a nuanced understanding of its maintenance costs and aesthetic value.

Each narrative illustrates a shift from initial skepticism or preference for traditional materials to a more informed appreciation of bamboo's potential in Balinese architecture, driven by personal engagement, aesthetic valuation, and practical considerations.

Cross-analysis

The comprehensive analysis, enriched by the survey findings and interviews with key figures such as Chiko, Thierry, Ketut, and Elora Hardy; reveals a complex web of factors influencing the perception and adoption of bamboo housing in Bali.

The sociocultural context emerges as a critical determinant, with bamboo traditionally viewed as a "poor man's material," despite its resurgence as a symbol of luxury and sustainability among foreigners. This dichotomy extends to the perceived costs of bamboo construction, where it oscillates between being seen as an economical choice and a premium material, dependent on the level of treatment, craftsmanship, and the project's scale.

The perceived lifespan of bamboo buildings is marred by concerns over durability and susceptibility to pests, although advancements in treatment methods and design innovations are challenging these notions.

Safety and flammability concerns, alongside the local availability of bamboo, underscore the material's practical and environmental merits. The sensory experience within bamboo spaces, marked by natural textures, light, and air circulation, highlights its unique aesthetic appeal.

However, issues such as lack of airtightness and the need for maintenance present challenges to its broader acceptability. Creative, original, and beautiful architectural expressions using bamboo underscore its potential for innovation in design.

Notably, the lack of stringent regulations on bamboo construction in Bali presents both an opportunity and a challenge, with the government encouraging the use of locally available natural materials. The adaptability of bamboo construction to urban and rural

contexts, as demonstrated in contemporary bamboo architecture, suggests a pathway for its integration into diverse built environments.

The analysis of the commentated walks and these participants' interviews further identifies additional indicators of perception and acceptability, such as maintenance concerns, which are pivotal for the longevity of bamboo structures, and airtightness (Table 1). The paradox of bamboo being perceived both as a low-cost and high-maintenance material indicates a gap in public knowledge and trust in bamboo's viability as a construction material.

Table 1: cross analysis of the participant's perception per indicator

Indicator	Ayu	Ade	Devi	Ngurah
Sociocultural Context	Prefers traditional materials, sees bamboo as cheap and eco-friendly but not durable enough for structural use.	Views bamboo as traditional, not suitable for urban settings but open to its use in rural areas or for furniture.	Sees bamboo as luxurious and expensive, with a mixed view on its suitability for personal use.	Appreciates bamboo's natural and healthy qualities but deems it impractical for urban use and too costly to maintain.
Perceived Costs of a Bamboo Building	Considers bamboo cheaper than concrete and wood.	Initially seen as unsuitable for serious construction but changes view to recognize its cost-effectiveness.	Perceives initial construction as cheaper but maintenance as costly.	Cheap to build but high maintenance costs, especially due to roofing.
Perceived Lifespan of a Bamboo Building	20 years, not long enough.	Initially thought 2 years, revised to more than 10 years, maybe even 20 after learning more.	5 to 10 years initially, but after visit considers it could last 15 years.	15 to 20 years, later adjusted to 20 to 25 years.
Perceived Safety and Flammability	Not specifically mentioned.	Not specifically mentioned.	Concerns about termites and dust.	Concerned about insect attacks.
Local Availability of the Material	Not specifically mentioned.	Not specifically mentioned.	Not specifically mentioned.	Encouraged by authorities but concerns about practicality in urban areas.
Perceived Sustainability of the Material	Views bamboo positively for its fast growth and environmental friendliness.	Acknowledges the environmental benefits and supports local craftsmanship.	Views positively but has concerns about maintenance and durability.	Recognizes as healthy and natural, but maintenance outweighs benefits for personal use.

Sensory Perception in Bamboo Spaces, Maintenance of Bamboo Buildings	Likes the natural look and colors, but mentions maintenance and durability concerns.	Positive sensory experiences lead to a shift towards trusting bamboo's structural capabilities.	Comfortable and peaceful, though mentions not smooth enough and concerns about mosquitoes.	Feels fresh and comfortable, nostalgic about childhood bamboo houses, but maintenance and cleanliness concerns.
Lack of Airtightness	Not specifically mentioned.	Concerns about heat in urban settings but appreciates natural air flow.	Concerns about mosquitoes due to lack of airtightness.	Airtightness not good enough for long-term living.
Creativity, Beauty and Originality	Appreciates the aesthetic of bamboo but prioritizes durability.	Finds bamboo constructions unique and original, especially after firsthand experience.	Likes the natural and healthy appearance, reassured by neatness of a 10-year-old house.	Admires artistic and natural qualities but outweighed by practical maintenance concerns.

Incorporating these insights into the evaluation of bamboo housing offers a nuanced understanding of its potential and limitations. Addressing the highlighted concerns through education, improved treatment methods, and innovative design solutions could pave the way for bamboo's acceptance and use in sustainable housing projects, bridging the gap between traditional perceptions and contemporary architectural practices

Each of these indicators brought up an aspect of how bamboo is perceived and whether or not it is accepted as suitable for housing.

Conclusion

This study focuses on bamboo as a sustainable material and its reception by local communities, providing insights for designers keen on integrating eco-friendly materials into their projects. It emphasizes the importance of preserving and promoting local craftsmanship and heritage in design, an aspect highly valued in sustainable design efforts. By adopting user-centered approaches and involving users in the decision-making process, architects can encourage a shift towards sustainable materials.

This research aims to offer insights for engineering, architecture, and potentially policy-making, underlining the potential for revitalizing bamboo as a sustainable material. The study primarily seeks to understand its acceptability for housing. Despite facing language barriers and potential biases in field interactions, such as interviews and commentated walks, the study acknowledges its limitations and the non-exhaustiveness of established indicators, suggesting the need for further research on bamboo's acceptability and perception in urban settings.

We advocate for bridging design theory with practical application through this research. By examining the actual use and perception of bamboo in a specific cultural setting, this study provides practical implications for theoretical design principles. Despite the findings being based on a limited sample and subject to biases from translation and respondent perspectives, they underline the importance of further, more extensive research.

This paper supports a mindset shift regarding the use of bamboo as a building material, emphasizing the need to consider project owners' and users' feelings of ownership towards the material for building sustainable housing and structures. This could also be used as a ground of reflection for architects and policymakers to support the adoption of bamboo construction projects in tropical regions.

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Generative Design Research Methods for Sustainability: Graduate Research and Design Interventions on Effective Use of Water

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ABSTRACT

This paper presents a course model, Generative Design for Sustainability, that brings together Experience Chart (EC) guide as a user observation method and two generative research methods, namely Design for User Intention (DUI) and Experience Reflection Modelling (ERM) for the various stages of a design research project and discusses their implications for design for sustainability. The course offered at METU Department of Industrial Design aims to provide graduate students with a basis for a better understanding of generative research approaches aligned with sustainable design considerations. It also helps students develop design solutions for sustainability, and evaluate and reflect on design research processes. First, the paper presents the course objectives, outcomes, and process, then, it explains the methods to be adapted and implemented within the context of the course. Then, these methods and their adaptations are demonstrated and discussed through design research projects of graduate students focussing on diverse practices such as showering, shaving, and personal care in a bathroom environment. The paper focuses on how the complementary use of generative research methods can support problem definition, idea generation, and convergence phases of the design process in line with the sustainability considerations for the *effective use of water*. Presenting major conclusions and insights, this paper offers a holistic perspective on conducting generative design research for sustainability in design education. It will also discuss potential adaptations of these methods for the future development of the course.

Keywords: generative design research d-methods, design for sustainability, effective use of water, sustainable behavior change, experience chart (EC) guide, design for user intentions (DUI), experience reflection modelling (ERM).

Introduction

Active and creative user involvement in the design process is crucial for delivering inclusive applications and promoting sustainability. User-centred research values people as the source of user knowledge through their involvement in design research.

Although user-centred design research appears to be widespread in the design process, people's participation in the early phases of the design process has increased to elicit people's tacit knowledge to understand better the context of experience and latent needs (Sanders, & Stappers, 2012). Participatory approaches aim to encourage and support the direct involvement of people in the design process to democratize decisions and solutions. Generative research emerged out of the participatory approach is used in the initial stages of the design process, and aims at eliciting and exploring user needs, expectations, and preferences (Hanington, 2007; Sanders & Stappers, 2014). It also enables design researchers to make interpretations and develop design ideas based on people's expressions revealed through the use of generative tools and techniques such as Velcro modelling, mind mapping, collages, diaries, etc. Making tangible things by using these tools would allow people to express tacit knowledge and latent needs that could be challenging to express verbally (Hanington, 2007).

Design thinking fosters the development of innovative, and inclusive solutions which address complex *sustainability challenges* because it offers a user-centred and collaborative approach to problem-solving via analytical and creative thinking (Tavanti, 2023). Design for sustainability enables locality and bottom-up mindset and empowers people in the design process in which participatory and co-design approaches are adopted (Manzini, 2015). Within the scope of the course theme, it is also important to understand individual tendencies to change behaviors and intentions to adopt responsible practices, which are often overlooked in efforts to promote sustainable water consumption (Oğur Aydın & Doğan, 2022). Therefore, adopting design thinking and generative research into the design process is crucial to inspire and support the exploration of sustainable solutions for effective resource use.

Course Content

This paper presents the main insights that emerged from the *Generative Design Research for Sustainability* course at the graduate level, which provides students with a foundation for a better understanding of generative research approaches in line with design considerations for sustainability.

The content of the course includes the following: *the exploration of the problem area* and the current issues in participatory and generative research approaches for integrating sustainable design considerations; *the examination of various generative methods and tools* used by design researchers; *the design and conduct of an activity and/or product-oriented design research project* incorporating sustainability considerations into these methods and tools; and *the discussion and presentation of findings and conclusions* from the generative design research project.

As part of the course framework, the course focuses on a particular theme that emphasizes the *effective use of water in the bathroom environment* considering diverse personas and practices for enabling sustainable behavior change. This timely theme is selected considering its relation with one of the sustainable development goals (SDGs).

In the 6th SDG, The United Nations has highlighted the importance of access to clean water, improving safe sanitation and hygiene services by 2030 by improving water-use efficiency and water management (The United Nations, 2023). In this graduate course, design students paired up and focused on a particular activity performed in bathrooms including showering, shaving, and personal care which are responsible for a considerable amount of water consumption.

Integrating Generative Research Methods

The fourteen-week course included several stages. In the beginning, the course instructors presented an overview of qualitative research and its implications for generative design research and examination of generative tools and techniques (Sanders & Stappers, 2014). The course introduces and adapts three generative research methods to explore the main theme. The selected methods were developed and adapted over the years within the context of undergraduate and graduate design education at METU Department of Industrial Design. Considering the phases of design process, *practice and user observations* oriented method (EC Guide) at the exploratory phase, *design for sustainable behavior* oriented method (DUI) for initial ideation, and *co-design* oriented method (ERM) for design detailing were selected. Thus, the students could explore the role and implications of each method in line with the design process. This link also helped them adapt these methods considering the design intervention areas of each student team.

Experience Chart (EC) Guide is an observational method with *enactment sessions* to explore and understand the practices and their phases, and users' existing behaviours shaped around practices. It guides design researchers while capturing and documenting user observations as part of exploratory research to inspire and inform early design decisions. The EC Guide starts with the empathy phase as a pre-observation stage and then continues with four main stages that are: participant & environment, observations, thinking aloud, and memories & dreams (Kulaksız, 2016).

Design for User Intentions (DUI) is a generative method that provides a valuable knowledge source and guidance for design researchers and practitioners to influence behaviours toward sustainable directions. It enables them to explore the problem area and the user, generate diverse ideas, refine the developed ideas, reconsider the ideas for different user intentions and support their design decisions. It includes a comprehensive card set (inspiration cards), a workshop procedure and various online tools and tasks to support early design phases for promoting behaviour change (Oğur Aydın, 2021).

Experience Reflection Modelling (ERM) is a design research method that emerged from participatory and generative approaches, which encourages people's involvement at the early stages of the design process and connects design students and potential users through creating an effective medium for collaboration. It brings together 3D modelling, interview, video recording and analysis techniques to help students better

understand user needs, experiences and expectations regarding a practice and related product (Turhan, 2013).

In the early stages, the students adapted **the Experience Chart (EC) Guide** with *enactment sessions* as an observational method to explore and understand the practices and their phases, and users' existing behaviors shaped around these practices in the bathroom. This also helped them identify problem areas and gain insights for the following stage of the course. The student teams then incorporated user research findings and insights into ideation by taking part in the **Design for User Intentions (DUI)** workshop and generated diverse ideas based on diverse personas for the selected practices focusing on the effective use of water. This divergence stage of ideation was followed by the refinement and further development of the design solutions by adapting the **Experience Reflection Modelling (ERM)** as a generative research method to gain insight into user knowledge and develop innovative design solutions.

The following section presents how each method was incorporated into the course stages in line with the design research process, including the identification of the problem areas by EC Guide, transferring them into the ideation phase (divergence and refinement) by DUI workshops, translation of the selected ideas into ERM sessions and their presentation. The graduate students who were enrolled in the course were mainly from industrial design background, except one with a bachelor degree in visual communication and design. Considering the overall number of students, four teams including pairs of students focussed on diverse design intervention areas (i.e., showering, shaving, cleaning make-up brushes).

Main Findings and Insights

In this section, the implementation of the generative research methods throughout the diverse stages of the students' design process is explored, drawing insight from students' evaluations and reflections on the adapted methods and their design processes aimed at promoting the effective use of water. The discussion primarily focuses on how the incorporation of each generative method supported the objectives of each design phase and contributed to the subsequent stages of the design process. Additionally, further insights into the course's development for future adaptations are shared.

Exploration and development of problem areas by EC Guide

The information gained through observing users can profoundly inspire the initial phases of the design process. Through receiving users' actual behaviors in specific scenarios and their natural context, these observations unveil unarticulated needs and preferences of users that are difficult to obtain. In this graduate course, considering that design students may need guidance while carrying out user observations and communicating their findings, the EC guide was incorporated as a complementary observation method.

The EC guide as a user observation method includes five stages to assist students in capturing and documenting user observation by emphasizing key considerations. It also provides an editable presentation board serving as a means of presenting their findings from user observations. The flexible nature of the EC guide enabled students to adapt its tool and presentation board template in line with the needs of the practices they focused on.

Built upon the evaluations and reflections of students, the incorporation of the EC guide into the user observations provided them with various forms of support. During the *empathy stage*, the students developed self-awareness regarding the intensive use of water in relation to their behaviors and got familiarised with the problem area. *The participant observation stage* assisted them in recognizing contextual factors shaping behaviors and also helped them understand the users and their habits. Through the *observations and thinking-aloud stage*, they assessed water consumption, connected it to the activity stages, elaborated on the problem area, and delved into the reasons behind behaviors leading to the intensive use of water. *The memories and dreams stage* served as a source of inspiration for potential design directions by highlighting significant problem areas, addressing user needs and expectations, and uncovering user attitudes toward water consumption. *The analysis and presentation stage* assisted students in analysing and categorizing the received information, emphasizing and communicating significant problem areas that would serve as a source of inspiration for design solution areas.

EC guide poster presenting the findings from one of the user observations (Figure 1) illustrates how students gain insights into the habitual behaviors of the user (e.g. *frequency and duration of showering*) through the enactment session the user carried out and probing questions that the student directed during the thinking aloud session. The challenges and dreams that the user shared revealed problem areas and design opportunities for sustainable behavior change (e.g. *difficulty in adjusting the water temperature*, and *reclaiming wasted water*). These featuring concerns inspired the early ideation phase of the students for the following stages of the project. EC guide presentation boards supported the effective communication of the user observation findings (Figure 1). While presenting the overall findings and insights, the student highlighted and related the specific problem and design solution areas (e.g., *fear of fall* and *feel of warm water for relaxation*) with the diverse stages of the practice of focus.

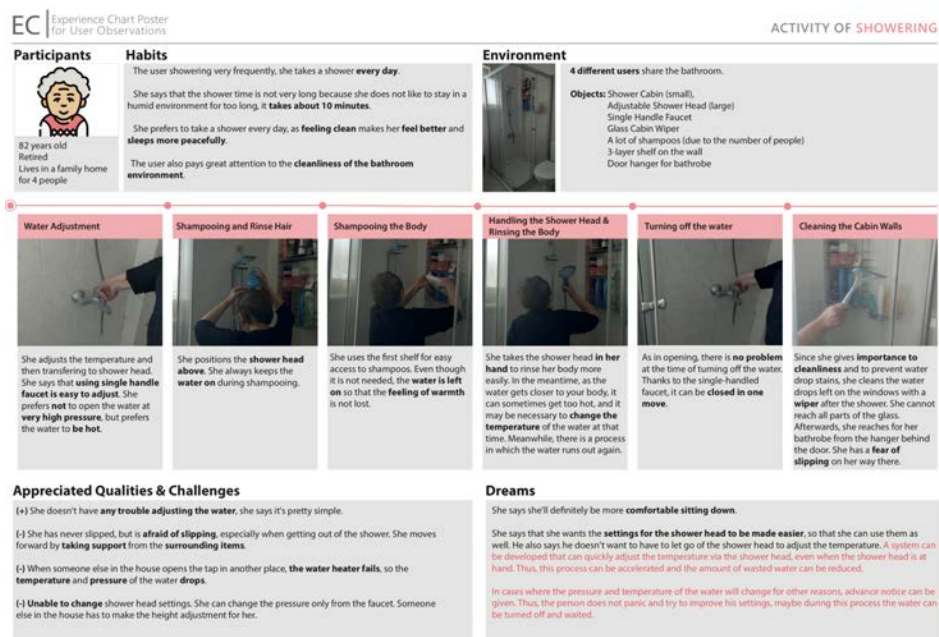


Figure 1: EC guide poster presenting the findings from one of the user observations.

Transferring user observation findings into ideation

The transfer of user research findings into the ideation phase and how this transition influences the design process hold significant importance in bridging the gap between design research and its practical application (Oğur, 2021). In the course, combining the EC guide with the DUI method supported students in evaluating the user research findings, generating problem areas and integrating those into the ideation phase.

The DUI method, through the tools (*inspiration cards*), tasks (*brainstorming, ideation, refinement, etc.*) and procedures (*workshop procedure*) it provides and guides the early ideation phase for the development of diverse ideas aiming for sustainable behavior change. Inspiration cards include various cards which communicate user research findings to designers and aim to contribute to the exploration of the problem area, the identification of the diverse user intentions for adopting change, and the recognition of the design strategies to inspire ideation phase for sustainable behavior change.

In this course, the students were expected to review and evaluate the existing card set and adapt it to align with the emerging problem areas in relation to the activities of focus (e.g. showering, shaving, cleaning make-up brushes). The DUI workshop included seven successive stages (i.e. *sensitizing, introducing, generating I, generating II, sharing and reflecting, refining and evaluating*). Through adapting inspiration cards and following workshop stages, the students first generated diverse ideas addressing various and different needs and expectations of users with diverse intentions to adopt

sustainable behaviors, and then they converged those ideas through the refining stage and presented their design interventions.



Figure 2: A section illustrating the students' process of transferring user research findings into ideation.

Based upon the students' final evaluations, they all acknowledged that the DUI method along with the tools and techniques as being very useful for *bridging the gap between user observations and ideation*. As transferring user research findings into ideation through the integration of inspiration cards, the students adopted different approaches. They (i) *redefined existing cards* to better reflect on the problem areas in relation to the activities of focus (e.g., perception of hygiene for personal products, personal feeling rather than water consumption), (ii) *developed new cards* (e.g. using non-watery washing methods for main purposes, need for disinfecting additional products) and (iii) *directly utilized the existing cards* matching with the issues they highlighted. Through this transition process, the students first transferred the identified problem areas to a shared Miro board, then they reviewed the existing card set by taking notes and evaluating their relevance with the activities of focus. Later, redefining existing cards or using empty card templates to develop new problem areas they created their own cards (Figure 2). The examples of these adapted cards involve the perception of time, personal feelings rather than water consumption, etc.

As user observations were carried out individually whereas this stage was carried out as a team, this stage also facilitated effective communication between the student team members by creating a shared understanding of the problem area.

Generating ideas for supporting sustainable behavior change by DUI

Designers intend to utilize the user research insights as a source of inspiration for fostering creative idea development. In doing so, they need guidance through potential approaches that they can incorporate into the ideation process. The tools provided by the DUI method, such as inspiration cards, offer a source of inspiration for generating ideas by highlighting the problem area, user needs and attitudes, and potential design strategies to students. Meanwhile, the workshop procedure offers guidance in the process of generating ideas aimed at influencing sustainable behavior change.

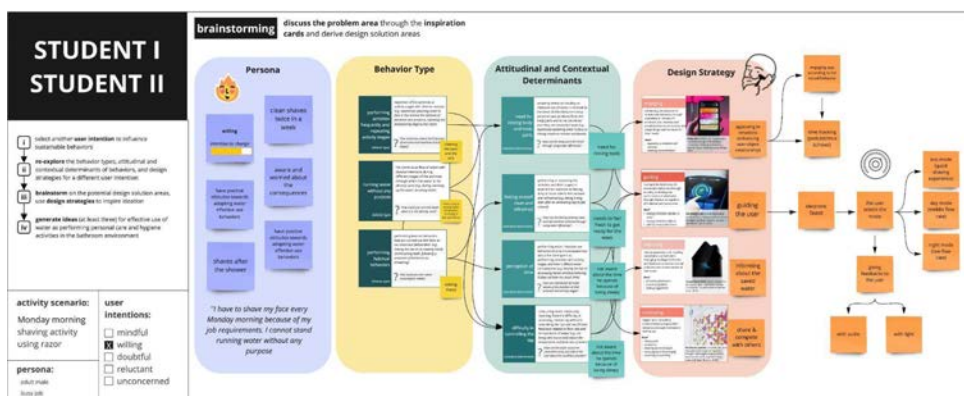


Figure 3: Brainstorming stage for shaving activity through the integration of adapted inspiration cards.

In the process of generating ideas for sustainable behavior change, students assessed the implications of the DUI method across four distinct contexts: *brainstorming*, *ideation*, *presentation* and *refinement*. During brainstorming, students initially selected a user intention (e.g. *willing user*) and created a persona by defining their needs, expectations and characteristics. The creation of a persona served to *diversify users and enhance the depth of usage scenarios*, ultimately *contributing to the variety of ideas* generated by recognizing various factors influencing water consumption behaviors. Following the definition of user intention and persona, the students identified behavior types responsible for intensive water use in relation to specific activities. As shown in Figure 3, one of the teams, for instance, selected three behavior cards (e.g. running water without any purpose, performing activities frequently and repeating activity stages, etc.) and connected those with the relevant determinants of behaviors (e.g. feeling oneself clean and refreshed, perception of time, etc.). Continuing the process, the students explored and selected relevant design strategies (e.g. engaging, guiding, etc.), proposed potential intervention areas (e.g. engaging app according to the user's mood and behavior, etc.), and categorized their ideas. This systematic approach facilitated a comprehensive *exploration of design possibilities to address and modify water consumption behaviors*.

As students brainstormed potential design intervention areas, they moved to the ideation phase and began visualizing their ideas through digital or hand sketches. During the second round of ideation, they altered the user intentions and developed a persona accordingly, and then they iteratively revisited the brainstorming and ideation stages. Switching user intentions, such as transitioning from *willing user* to *unconcerned user*, *supported the generation of diverse ideas* by the students. Recognizing and addressing various behavioral patterns among diverse users is stated to enhance the ideation phase, *fostering the creation of quick and diverse ideas* for sustainable behavior change. One of the teams, for example, considering the needs of the unconcerned users suggested water steam to heat the environment, massage mode for relaxing with less water, and collecting water while heating for later use (Figure 4). The very same student

team focusing on the mindful users, this time generated ideas aiming to inform the user about individual water consumption and offering suggestions for reducing water use, personalizing the showering mode for accommodating diverse needs and encouraging product part maintenance and repair through providing videos or schemes (Figure 4).

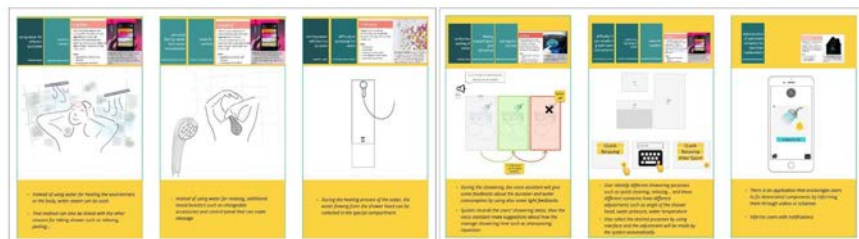


Figure 4: Development of diverse design interventions for showering activity through altering user intentions.

While presenting their design interventions, students preferred to relate the ideas with the identified problem areas, characteristics of their persona and design strategies that they found inspirational. This approach enabled them to *justify their design solutions through better connecting them with the problem area*.

Following the presentations and feedback session, the students were tasked with evaluating and compiling their ideas to refine and advance a single design intervention aimed at promoting the effective use of water while performing activities of interest. The students referred to this stage as a helpful step for *compiling their initial ideas* at the early stages, *evaluating and reconsidering their design solutions* in line with the received feedback. This phase also aided them in *reconsidering the relevance of the generated ideas to the defined problem area and user intentions*. In the refinement stage, one of the student teams initially categorized the emerging ideas that hold potential for the effective use of water and selected promising ones for further compilation. They proceeded to develop these ideas, visualized them, and created a showering scenario in which the design intervention is utilized by the user in the diverse stages of the activity (Figure 5).



Figure 5: Compilation of ideas during the refinement stage.

Translation of refined ideas from DUI into ERM sessions

ERM enabled the students to assess and further develop their refined design ideas with a focus on sustainability considerations by active involvement of actual users. The

students developed and finalised an ERM toolkit and interview schedule considering the selected practices with an emphasis on the effective use of water. In addition to this, each team conducted two ERM sessions with users. In the ERM sessions, participants built, tested, evaluated and discussed the design solutions for effective use of water by bringing together the components of the toolkit and responding to interview questions in line with a use scenario. The interview schedule featured questions strategically aligned with a use scenario, helping the teams investigate each step. This approach facilitated a more comprehensive exploration of user needs, expectations, and potential challenges associated with the proposed designs.

The students developed their ERM toolkits which roughly represent their design ideas. The toolkit development for the students' refined ideas can be explored under three main categories: (i) *use of diverse materials and components for personalizing the toolkits*, (ii) *incorporation of timelines in the toolkit* and (iii) *strategies employed by teams to build use context within the ERM toolkit*.

An ERM toolkit is composed of 2D and 3D parts which have the potential to represent components of an idea. In addition to the predefined parts, different materials such as play dough, coloured papers and pens, fabric, wire, and so on can be added to the toolkit not only to meet the request of the participants but also to provide them with various alternatives for personalisation of their physical 3D models. At this stage, the students' ideas were at the conceptual level making the abstraction of components challenging. So, they developed different alternatives of components, geometric shapes, and surfaces (Figure 6a).

In addition to 3D components and additional materials (e.g. play dough, coloured pens and papers, etc), they also added 2D representations of icons for paper prototyping of digital user interfaces, and flat surfaces with graphics representing various textures (Figure 6b). As shown in Figure 6, the toolkit involves a variety of scales and volumes to represent a function or component, such as a water reservoir for shaving, interface elements/indicators for adjusting water, etc.



Figure 6: ERM toolkits (a) different shapes, sizes, and materials, (b) components representing digital solutions.

Many teams incorporated a timeline demonstrating the flow of the activities into their toolkit to facilitate the session. Two distinct approaches emerged: some teams prepared a pre-set timeline based on the interview schedule order, while others prepared a more

flexible timeline allowing participants to adjust it during the session (Figure 7). It enabled a systematic questioning process aligned with the timeline (e.g., *pre-cleaning without water, cleaning, rinsing, drying, and other for cleaning make-up brushes*), aiding users in navigating the stages of 3D model construction and scenario enactment.



Figure 7: Timelines used in ERM sessions; (a) stages of the make-up brush cleaning activity, (b) stages of the showering activity.

The student teams conducted ERM sessions with two users in separate instances. As these sessions were not conducted in real settings, different strategies were employed by teams to build a meaningful use context within the ERM toolkit. The students stimulated the use contexts with the ERM toolkits. For instance, one team utilized mobile panels to represent bathroom walls, allowing participants to attach toolkit components (Figure 8a). Another team abstracted the countertop and sink environment, enabling participants to enact scenarios in this modified setting (Figure 8b).



Figure 8: Simulation of use context (a) grid panel (b) abstracted countertop and sink.

During the ERM sessions, students asked questions to the participants by using the schedule. In response to that, the participants expressed their thoughts as they brought together the components of the toolkit. The students utilized ERM to assess and refine design ideas, focusing on water efficiency. They developed a comprehensive ERM toolkit and interview schedule and conducted sessions with real users.

Analysing and visualizing ERM sessions for design directions

Student teams analysed the ERM sessions to gain insight into the data and developed design directions for their proposed ideas. In this process, they first verbatim transcribed the session by software (e.g. *O-transcribe*) and then transferred the data to *Excel* or *AirTable* for content analysis. They adopted different strategies for the data categorisation, yet they ended up with main themes and subthemes, design insights that emerged from the ERM sessions in relation to the solutions and effective use of water, and design directions to develop design solutions further.

The students prepared and presented posters, as one of the learning outcomes of the course is the discussion and presentation of findings and conclusions from the generative design research project. They presented their themes and subthemes by visualizing the data and supporting them with images and quotes from the ERM sessions. They also included their insights into the data, conclusions and main design directions to develop their ideas.

As the ERM analysis was multi-layered and comprehensive, they employed different approaches to visualize the data on presentation boards. The relationships between themes and subthemes were clear and supported by visuals. In some teams, they were clearly distinguished, while in others they had common sub-themes (e.g., *perception of hygiene and perception of cleanliness; personalised process and ergonomic convenience, etc.*) related to more than one main theme (Figure 9). Some groups also used visual patterns associated with the themes to visualize the frequency of data. For example, in Figure 9, the intensity of small circles around a theme indicates the frequency of it in the data.

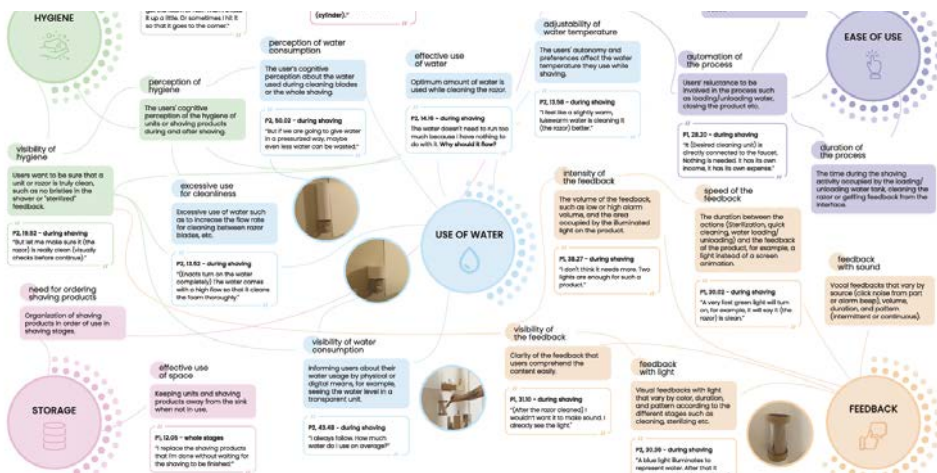


Figure 9: A scene from the ERM analysis presentation.

Personalization and adaptability to user needs and preferences were some of the most mentioned themes across all activities. *Type of feedback*, regardless of the being provided in a physical or digital format, *motivation to use the design proposal* and *ease of*

use are other themes that emerged from the ERM analysis. *Perception of hygiene* and *visibility of water consumption* were prominent themes linked with the effective use of water. The student teams, concentrated on physical product ideas and developed design insights mainly related to the components of the products. For the digital solutions, findings were mostly related to *visibility of feedback*, and *engagement and motivation of users by gamification, informing and goal setting*.

Making a poster presentation allowed the students to visualize essential points and to highlight the considerations that were related to the design proposal, and the interconnection between the findings.

Conclusion and Discussion

The complementary use of innovative and generative research methods can be beneficial in aiding various phases of the design process, particularly when aligned with the considerations of design for sustainability (Wever, et al., 2008) and design thinking (Brown, 2008). Ensuring a user-centric approach through design thinking empowers designers to develop innovative and sustainable solutions. In this graduate course, the integration of the *EC guide* facilitated the observation and in-depth questioning of users' experiences that are challenging to acquire verbally. The *DUI* method facilitated the development of diverse ideas by considering different problem areas and different users' tendencies for effective use of water, compiling different ideas and problems, and addressing the problem area in a multidimensional way. The *ERM method* supported the development and refinement of the focused idea based on user preferences and needs through testing the design interventions with the users. Each method has areas for further development and intervention for future applications.

Reflections on the EC guide: The incorporation of the EC guide into the user observations can be regarded as an effective roadmap for design researchers, providing them with support in multiple ways. However, the facilitator may find it challenging to simultaneously take notes, record videos, observe user behaviors and interactions, and ask probing questions. To address these challenges in the course's future adaptations, conducting this stage in pairs can be considered as a solution to overcome these difficulties. The EC Guide template could also be tailored to the specifics of the practice rather than using it as it is. The observation guide and presentation template bear similarities in terms of reflecting on the experiences of each phase of practice. The allocated spaces for each part within the EC guide could also be adapted and rethought. However, that type of adaptation did not occur due to the time limitations considering the course timeline.

Reflections on the DUI method: The DUI method comprises several complementary stages, tools and tasks that support *brainstorming* for potential design solution areas, *ideation* on initial design interventions, *presentation* through linking the generated ideas with the problem space and *refinement* of the ideas for promoting effective water use. Emphasizing the comprehensiveness of the workshop, the student teams recommended

allocating more time to the facilitation of the workshop in the future adaptations of the course. The existing inspiration cards were found very inclusive for addressing diverse issues in relation to the effective use of water in the bathroom environment, yet some were not applicable to the activities of focus. Some of the student teams managed to better link the EC guide with the DUI workshop, and transfer user research findings into the brainstorming phase by identifying new cards or adapting existing cards. Utilizing a systematic approach through the templates and guides that the DUI offers supported students' during the conversion of research findings into ideation. For the presentation of ideas in the DUI workshops, the students were provided with a flexible template board, yet incorporating a template or a checklist to present their ideas in a more organized way is recommended. The presentation of the ideas and receiving feedback from the course instructors and peers were found productive for developing their ideas accordingly during the refinement stage. The instructions for guiding stages supported them to facilitate this phase within a limited time.

Reflections on the ERM method: ERM consists of preparing the toolkit and interview schedule for the sessions, conducting the sessions, and analysing the data. During the ERM sessions, considerations related to physical features and ergonomic concerns were easily observed, while receiving participants' insights related to the effective use of water was more challenging. This may result from the non-visibility of the water used while enacting or describing activities during the sessions. In future ERM sessions, different visual, audio and tactile tools could be developed to visualise and represent resource consumption.

The qualitative analysis phase poses a challenge for some of the graduate students, leading to an iterative process to finalize the themes for suggesting design directions for their design proposals. Based on the students' evaluations and reflections, they believe that they can apply this analysis method to their other studies, as it is adaptable to any other qualitative data. On the other hand, the main challenges for students were mainly on categorising the extensive amount of data and understanding the difference between insights, observations, and quotations. For the further implementation of this method, allocated time to analysis can be extended and practical exercises with examples can be provided to help students better grasp the analysis process. In terms of the adaptation of the ERM toolkits, some teams had more specific design solutions that emerged from the DUI workshops and experienced challenges in diversifying the toolkit components. The overall reconfiguration of the components for different ideas was narrowed down in the initial phases. For some teams, the flexibility and variety of toolkits were better utilized which helped the teams get more comprehensive feedback on diverse alternatives in line with participants' needs and preferences.

Future directions and suggestions for further adaptations of the course: The selected and applied methods are most effective in practice-based research where the researchers could observe and explore the stages of that specific practice to develop design solution areas and reflect on the process. The adaptation of each method is a lengthy and demanding process if the students lack the experience of qualitative

research methods, specifically during the analysis phase. All three methods were planned as complementary, referring to the specific phases of the design process starting from user observations to divergence and convergence stages. The main focus of this course was the effective adaptation of each method within the design process rather than design solutions; however, for future applications and other courses, they could be utilized and considered as exploratory and novel ways of developing ideas by adopting a co-design approach, where the focus would be on the design solutions. Different combinations of each method could also be considered in line with the main theme of a course. If the theme focus is more on the design for sustainable behavior change, then EC Guide and DUI could be coupled and planned within a course context. If the participatory co-design approach is emphasised then the EC Guide and ERM could be used as complementary methods. Incorporating all three methods has many benefits for understanding user experiences thoroughly, and exploring and reflecting on design interventions in line with sustainability, and effective use of resources.

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Supporting Reflexivity and Action on Equity and Justice in Design Education: Insights from the Design Justice Pedagogy Summit

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ABSTRACT

As engineering shifts to center and prioritize socio-technical problems, topics such as sustainability, equity, and justice are becoming increasingly engaged within engineering. Engineering education and other design education fields are seeking to incorporate equity, ethics, and justice considerations into design curricula to embrace this change and meet calls for supporting human flourishing such as the United Nations' Sustainable Development Goals (UN-SDGs). To accomplish this meaningfully and successfully, design education instructors are seeking guidance and support to embed these concepts into their courses. In this paper, we explore the Design Justice Pedagogy Summit, where design instructors engaged with keynote speeches, panel conversations, and three interactive activities. An "initial step" workshop, syllabus "makeathon", and policy envisioning activities supported instructors in planning changes for their courses to embed equity, ethics, and justice content and charting out sustainable paths for the future. Our work advocates for increased documentation of embedding design justice into design education, building communities to support instructors to engage with these topics, more teaching resources for instructors on these topics, and industry incentivization to center equity, ethics, and justice in design education. Through these actions, we can support instructors and university institutions in sustainably engaging with design justice as a way to work towards reaching the UN-SDGs.

Keywords: design justice, design education, reflection, envisioning

Introduction

Achieving the UN-SDGs requires engineers and designers to be trained in working on complex socio-technical design challenges through equity-centered lenses (Chen, Jeronen and Wang, 2021). The UN-SDGs center sustainability as a “paradigm for thinking about the future in which environmental, societal, and economic considerations are balanced in the pursuit of an improved quality of life” (Idowu *et al.*, 2013). Quality of life in this definition is supported by several equity and justice-related concepts, including gender equity, cultural inclusivity, and “building just and peaceful societies” (Chen, Jeronen and Wang, 2021), demonstrating how interlinked the UN-SDGs are to equity and justice. Therefore, we anchor our work in design justice (Costanza-Chock, 2018, 2020), a framework that centers equity and justice in design, to support quality of life as defined by the UN-SDGs. As we work toward achieving the UN-SDGs, education is a critical component (Chen, Jeronen and Wang, 2021), echoing calls for engineering education to cultivate socially minded engineers to support social justice (Leydens and Lucena, 2017b). Social justice in engineering education is often rendered invisible because engineering is interpreted as technical problem-solving without the need to consider social contexts (i.e. a “social vacuum”) and is depoliticized separate from political and social contexts (Leydens and Lucena, 2017b). These ideologies, along with biases and techno-solutionism to name a few, create barriers for engineering to engage in social justice work (Leydens and Lucena, 2017b). However, we know “there is a certain amount of overlap between the kinds of problems engineers solve and social justice problems, although the engineering approach may not define the problem to be solved in terms of social justice” (Riley, 2008). To shift education to support social justice, and therefore the UN-SDGs and for engineering to redefine problems for social justice successfully, it is critical to reduce these barriers and reshape design pedagogy, supporting instructors in embedding social justice topics (Das, Ostrowski, *et al.*, 2023).

Previous works have built on this call for redefining engineering education for social justice. The Engineering for Social Justice (E4SJ) criteria aim to “increase the probability that social justice is enacted in multiple phases of design work” and “provide ways of answering crucial and often neglected questions regarding what engineering is for?” (Leydens and Lucena, 2017a), encouraging reflection and critique of engineering work. Other works have called for cultural shifts in engineering and, subsequently, reframing engineering education. Burleson *et al.* (2023) advocate for reimagining the content and pedagogies of engineering education that are historically grounded in supporting some groups advancing economically while preventing others. Engineering can also support students in building socio-technical skills through extra-curricular, co-curricular, and curricular opportunities in higher education (Burleson *et al.*, 2023). Overall, to create a culture shift in engineering education that values equity and justice and encourages students to interrogate the social complexity of engineering, we first need to work with instructors to support them in embedding this content into their design courses in a sustainable manner. Our work addresses a gap in design education by connecting engineering with socio-technical issues like equity and justice (critical areas for

achieving sustainable development and human flourishing) by supporting instructors to implement this content. Our work explores how the format of a summit with interactive activities focused on embedding equity, ethics, and justice into design curriculum could support instructors in developing strategies and envisioning the future of these concepts in engineering education and university institutions, broadly.

The focus of this work, the Design Justice Pedagogy Summit (DJPS), was developed to support design instructors to deepen their engagement with design justice considerations in their pedagogy and practice. The DJPS was structured with design justice (Costanza-Chock, 2018, 2020) as its foundational theory, building from previous work that has audited engineering education and other engineering spaces through a lens of design justice (Das, Ostrowski, *et al.*, 2023; Das, Roeder, *et al.*, 2023). The DJPS was organized as a three-day event featuring keynote speakers, panels on topics such as “Challenges and Opportunities in Engaging Equity, Ethics, and Justice in the Classroom”, and three interactive activities: a workshop on initial steps for change, a syllabus “makeathon”, and policy envisioning session. Each of these activities was designed to support instructors in reflecting upon their current design course curriculum through a design justice lens, generating steps for change in their courses, imagining the future for design justice in design education and planning how we can reach sustainable change for a design justice-based design education. Our work revealed how participants reimaged their courses to support design justice in short-term and long-term contexts, prioritizing community and resources. The contribution of this work is introducing and analyzing the impact of three activities from the DJPS that promote reflection on and embedding of equity and justice into design pedagogy. The activities and their impact discussed in this paper can ensure sustained engagement with equity and justice topics, empower sustainable design practices in design pedagogy, and support meeting the UN-SDGs.

Background

Design Justice

Design justice is a relatively new framework that supports designers in considering how benefits and burdens of designed objects are distributed (Costanza-Chock, 2018, 2020). Stemming from the Allied Media Conference in 2014 and building upon Black feminist scholarship, including the matrix of domination (Crenshaw, 1989; Collins, 2002), design justice has become a larger community of practice through the [Design Justice Network](#). Design justice promotes and “ensure[s] a more equitable distribution of design’s benefits and burdens; meaningful participation in design decisions; and recognition of community-based, Indigenous, and diasporic design traditions, knowledge, and practices” (Costanza-Chock, 2018). Increasingly, design justice has been adapted and translated to specific design contexts, including engineering design (Das, Roeder, *et al.*, 2023). Das et al. (2023) specifically highlighted the need for engineers to incorporate equity, ethics, and justice into engineering design spaces as there was a lack of attention to these topics. Meaningful incorporation of design justice into design and engineering

education can be used to support the UN-SDGs, as it serves as a framework for reducing inequity and promoting inclusive and just institutions and development. In our work, we engage with equity and justice concepts through design justice to support design instructors in educating the next generation to design and support sustainable futures and meeting the goals of the UN-SDGs.

Design Justice in Education

Design justice has been used in design education to evaluate how current courses incorporate design justice concepts. Previous work has identified a lack of emphasis on design justice in engineering design education specifically and the need for increased support for instructors to embed these considerations (Das, Ostrowski, *et al.*, 2023; Das, Roeder, *et al.*, 2023; Ostrowski *et al.*, 2023; Saadi *et al.*, 2023). Das *et al.* (2023) found that there was less design justice content in engineering design courses compared to non-engineering design courses, signaling the need for more attention to equity, ethics, and justice in design education. In a survey of design courses, instructors emphasized the need for social, policy, and ethical considerations, though they identified several barriers for embedding this content in design courses (Saadi *et al.*, 2023). These included lack of time and educational materials for including this type of content and some questioning of the relevance of this type of content (Saadi *et al.*, 2023). While there has been less presence of design justice-related content in engineering design courses and several barriers for engaging with this content, there is opportunity for supporting instructors in embedding this type of content in design courses. Instructors from the survey noted that more educational resources, prioritization of social, policy, and ethical considerations in design curriculum by academic institutions, and financial support could better support instructors (Saadi *et al.*, 2023). Previous work has also proposed a set of nine pedagogical approaches for embedding design justice into design courses, including “embed[ing] topics on the societal impact of technologies”, “be[ing] aware of the systems and context surrounding technology design”, and “support[ing] reflexivity and empowerment in technology design” (Ostrowski *et al.*, 2023). Works on supporting design justice in design education have also connected to sustainability, such as the concept of sustainability being a gateway to bringing design justice into courses (Das, Roeder, *et al.*, 2023) and the pedagogical approach of “engag[ing] with topics around sustainability” (Ostrowski *et al.*, 2023). As we further promote embedding design justice topics into design courses, we need to provide support to instructors, create opportunities for instructors to reflect upon how best to integrate these concepts, and critically consider how these changes can be sustained within academic contexts.

Methodology

Our work explores two research questions: RQ1: How can we support equitable design through design education?; RQ2: How can we leverage design justice as a foundation to support instructors in embedding equity and justice into design education?

Research Context

The DJPS was held over three days in August 2022, and included keynotes, panels, and activity sessions (Figure 1). The event was designed to support instructors in embedding design justice in their courses and identify strategies that educators planned to use to accomplish this. Participants were recruited through social media posts, emails to design instructor listservs, and the Design Justice Network. 38 people participated in the summit, representing 17 United States-based academic institutions, non-profit organizations, and industry companies. 33 participants consented to participate in the research (86.8% of overall summit participants).

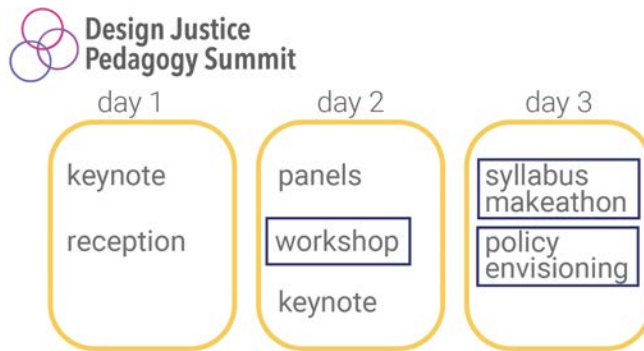


Figure 1. DJPS format with the three activities explored in this paper highlighted.

Data Procedures, Collection, and Analysis

This paper focuses on three activities that occurred during the second and third days of the Summit: a workshop on taking the first step to reflect and embed design justice; a syllabus “makeathon”; and a policy envisioning session. Following panels on the second day, participants engaged in the interactive workshop (Activity #1), where they could focus on either bringing social justice content into a technical course or engaging social justice principles in workplace education and training. The workshop asked participants to identify one initial thing that they would like to change in their activity or course and the support necessary to implement this change.

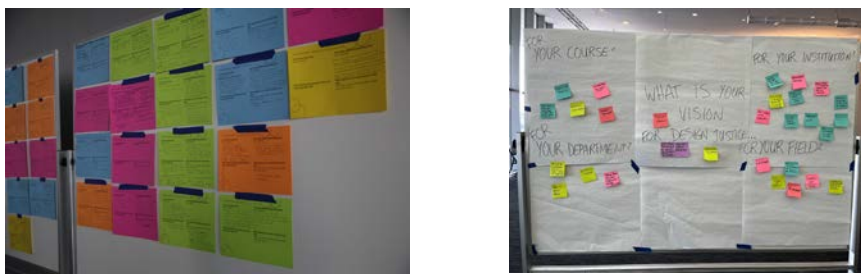


Figure 2. Outputs from the workshop activities. (Left) Design artifacts from the interactive workshop (Activity #1); (Right) design artifacts from the policy envisioning activity (Activity #3).

On the third day, participants engaged in a syllabus makeathon (Activity #2) and policy envisioning event (Activity #3). At the beginning of Activity #2, participants did a gallery walk of the workshop outputs from the previous day to explore the changes that participants were thinking of incorporating into their work. They then documented all of their ideas for their course, reflected on how those ideas related to incorporating equity and justice considerations, and considered their long-term goals for the course. In Activity #3, participants created goals around design justice in higher education as a whole including at the department, institution, and/or academic field level.

Participants' written worksheet responses to the activities were scanned, transcribed, and qualitatively analyzed. Two researchers reviewed the data thematically (Braun and Clarke, 2006), individually creating a list of themes. The researchers discussed the themes and created a final list to code the worksheets. Each question of the worksheet was first individually thematically analyzed (Braun and Clarke, 2006) by two researchers who then reviewed the coding together to resolve any disagreements.

Results

Our results demonstrate how instructors engaged with design justice and considered the sustainability of design justice in design education throughout the DJPS activities. We provide a selection of analyzed themes that relate to changes to design education, sustainable change, and reflection.

Activity #1: Workshop Activity

In the workshop activity, 24 participants brought a course or program and brainstormed how they could incorporate more equitable or just practices. Analysis of a subset of the *guiding questions* from the activity are included in this section for their relevance toward sustaining engagement with equity and justice topics.

The first prompt asked participants to note *initial steps to incorporate design justice*. The most common technique involved **changes to course methods**, with 54.2% of participants mentioning some form of change to the structure or content of their course. This included introducing guest lectures, changing or adding readings for a class, rethinking course objectives, integrating journal prompts, involving the community in assignments, and introducing case studies related to design justice applications.

Some (41.7% of participants) mentioned broad changes reflecting a general **mindfulness toward design justice themes** without specific mention of a technique. Some examples of this included a course that "considers identity" and in which "norm setting is collaboratively done," (p29 (i.e. "Participant 29")), "building accountability on what this gr[ou]p is for and what it's not" (p29) or "emphasiz[ing] DEI [diversity, equity, and inclusion]" (p13). An array of participants mentioned collaborative processes in their initial steps. Some touched upon **community-based/co-design** (16.7%) practices in describing the importance of engaging and working with the community in their designs. Similarly, others mentioned a **user-centered** (12.5%) approach that

contemplated a design's target audience without explicitly engaging the community. Others discussed **vulnerable and mindful listening** (25%), either in the classroom or with these partners. This included listening to the "voices of those directly impacted" (p28) through "appreciative inquiry" (p22), "dialogue over difference" (p05), and storytelling. Others spoke of **broadening awareness of design justice to their colleagues and peers** (8.3%) by speaking about design justice at conferences or talking to their teams and students at more local scales.

Other common methods centered around **reflection** (20.8%). Some mentioned adding reflection exercises to their courses, like "engag[ing] students in reflection about the nature of the projects and the inherent trade-offs between their own learning experiences and objectives vs. the social benefit for community partners" (p01). More specific forms of reflection consisted of **reading analysis** (16.7%), which embraced taking the authors' identities and viewpoints into consideration when selecting or synthesizing literature and **analysis of past problems, designs, or work** (25%), which contemplated how prior products or practices may have affected their communities or caused harm. Some referred to incorporating **land acknowledgements and indigenous knowledge/cultural heritage** (20.8%) into their courses such as case studies or emphasizing the "'presence' and 'visibility' of all cultures" (p13). Some participants (16.7%) had **open questions** that they left for consideration – such as "Does the dominant culture dominate class?" (p08) or "Are we prioritizing specific backgrounds in design (vs. product offering prioritization)?" (p20).

The second question of interest in the activity asked participants: ***What support do you need to take these initial steps.*** As important as the initial steps were in starting reflection, considering the support needed is crucial for changes to thrive. Broadly, participants looked to **consulting others** (50%). This included seeking advice from colleagues or other connections to incorporate design justice in their work, discussing next steps with teaching teams, and building and relying upon their communities. This demonstrates the importance of maintaining networks and community. Complementary to this idea was **co-creating/co-developing** (16.7%) curricula with the community.

Many noted that they needed to **learn more** (33.3%) before incorporating design justice into their courses or work. Some mentioned wanting access to readings, case studies, and examples of successes and failures to inform their process or a desire to conduct further research on design justice. However, well-informed decisions are crucial for securing **buy-in** (20.8%) from institutions, departments, and colleagues, a major area of support that participants mentioned needing. Some initial steps that could support participants were course **syllabus review and editing methodology** (20.8%) using a design justice lens, **gathering course materials** (16.7%) that prioritize equity, ethics, and justice, and **practicing implementation** (16.7%) in their courses or research.

Activity #2: Syllabus “Makeathon”

The second activity in the summit was a syllabus “makeathon”, in which 17 participants used the workshop outputs from their peers as inspiration for redesigning their courses. One focus of this activity was a **Moonshot**, in which participants outlined their “big picture aspirations” for their course in the future as they continue to incorporate design justice. The most popular theme involved **implementing design justice** (58.8%) in “credit bearing and non-credit bearing experiences” (p10), and many instructors hoped that design justice would translate to a key **learning outcome** (29.4%) for students. More than this, instructors wished to **empower their students as changemakers** (47.1%) and foster students’ and designers’ confidence in creating change in their communities. Sometimes, this manifested itself through **advocacy** (17.6%). This ranged from advocating for “ethical practices” (p21) and “accessible medtech” (p16) to “the inclusion of design justice principles in their future organizations” (p12).

Some participants’ Moonshots outlined more systemic reaching beyond their courses. One such wish was a **restructured academic system** (17.6%). This entailed institutional changes, like “increasing the justice norm across other courses” (p17) or departments, as well as large-scale “academic ecosystem” changes such that the “system will work for everyone who is motivated to join the profession” rather than “weed out people” (p09). People also expressed that they want more **opportunities after graduation that value design justice** (17.6%). This could be through “founding new organizations” or “joining existing organizations and influencing their mission” (p16). It could also reflect a general desire that “students are both equipped and motivated to co-create societies in which they and others thrive, and, crucially, there are abundant post-graduate opportunities for them to do this” (p02). As a whole, some (5.9%) expressed a wish that “**design is accepted as a rigorous area in engineering**” (p12).

Many participants used the Moonshot activity to outline mindful practices they hoped to adopt. One such way was through paying attention to **ethics and bias** (29.4%) in the design process and in the classroom, like by implementing an ethical “review process” (p21), practicing “ethical engineering that includes design justice principles” (p12), or “unpacking BIAS[ED] DATA SETS” (p11). Participants often underscored **DEI as a guiding principle** (41.1%) in their spaces. Some took to this by **valuing identity** (17.6%) in their design efforts, as “it’s important to understand students’ prior experience” (p07), because it often “informs behaviors” (p20). Others touched upon **critically interrogating systemic issues** (41.1%). They wanted their students to “be critical of their work and be realistic about the benefits/harms of their work” (p12).

Activity #3: Policy Envisioning

The final activity of the Summit was the policy envisioning session, in which 17 participants devised a “**blue-sky**” vision for the future, came up with **barriers** to that vision, reconstructed a “**realistic**” vision, and brainstormed ways to work together to move forward and **bridge the gap** between the two.

The majority of participants referenced heightened **diversity and equitable access** (52.9%) as being integral to their “blue-sky” visions. This entailed institutions “serving a wide range of students taught by broadly diverse faculty” (p08) and “full usability” and “accommodation” for “faculty, staff, students, [and] contractors” (p15). Another large desire was for the **integration** (41.2%) of design justice into “how we work” (p01) and in “each person’s core job description” (p11). Many underscored the need for heightened **collaboration** (35.3%) within newly formed or existing communities engaging **cross-disciplinary** (23.5%) connections. Some suggested **curriculum change to build changemakers** (23.5%), where “all rules are there because they support student learning” (p09) and “continuous inquiry” (p29), while others emphasized a goal in which there are **resources** (29.4%) and **incentivization** (23.5%) to implement change.

The same set of themes was used to describe the “blue-sky” and “realistic” visions, but these themes appeared differently in the two visions, particularly in terms of the frequency of their appearance. Most themes diminished in their appearances from the “blue-sky” to “realistic” vision. **Collaboration** (29.4%) became the most referenced theme, and a hope for **common resources and understanding** (23.5%) was deemed to still be realistic by a number of participants. The themes that saw the greatest decrease between the two visions were **diversity and equitable access** (52.9% to 17.6%) and **integration** (41.2% to 11.8%) of design justice into their spaces.

The predominant barrier to implementing these blue-sky visions was **resistance to change** (70.6%). Many articulated fears of “defensiveness” (p01) among “engineers who think the work is ‘too political’ to get involved in” (p26). However, even with minimal external friction, some instructors didn’t feel equipped to advance design justice due to “lack of **expertise** [(17.6%)] in the field” (p07). They worried that they would err in **implementing design justice** (23.5%) and thus “the system [would] be abused” (p16). Meanwhile, some don’t get the opportunity to act at all due to “social structures [and/or] barriers” (p07) that bar **equitable access** (17.6%). Another hurdle to advancing design justice was acquiring adequate **resources** (52.9%) for changes, both with respect to “funding” (p28) and “time” (p20). However, even when time and money are available, **incentivization** (35.3%) proved to be an issue, as “most institutions have enough of both but don’t want to spend either on this work” (p26). If buy-in is eventually secured, many reported difficulties and fatigue in **staying engaged to make change** (17.6%).

To work together to move toward the visions, a key element was **process-oriented change** (41.2%). This entailed working “top down” with higher-ups and “bottom up” (p08) with faculty and students to “codify... changes” (p09), “finding allies within the institution and allies externally” (p16) to advocate progress and laying the groundwork for change even when one lacks the direct power to make the changes themselves. To this end, **collaboration** (41.2%) with communities, and in a design context, “user-centered” (p20) visions, was similarly vital. Improving **diversity and equitable access** (35.3%) “across disciplines [and] fields of knowledge” (p05) was both a means and an end of advancing design justice, as “fresh minds with renewed interests” (p18) are pivotal in creating change. A strategy specific to this activity was combining **data**

and narrative to “speak... about real experiences” while “finding examples” (p16) to advance design justice. Another was making more room for **documentation and measurement** to “establish benchmarks and metrics for success” (p01). Overall, throughout all the activities, participants reflected upon their work and how they could sustainably embed design justice into their spaces.

Discussion

A major takeaway from the summit analysis is the power of community in implementing design justice. In all activities, participants underscored the need for engaging with their communities and partaking in interdisciplinary collaboration. This included bringing in the voices of those impacted by designs or technology, learning from peers and colleagues with similar justice goals, building networks dedicated to these goals, and working with, not for, stakeholders. Some found the existing Design Justice Network to be a helpful resource that could maintain the connections they made at the summit and introduce them to fellow justice-minded individuals. Collaborations such as this appeared both in participants’ goals for the future as well as in their plans for reaching those goals; collaboration was not only a means to an end, but rather a means *and* an end in integrating design justice (as seen in Ness *et al.*, 2010). Community-building thus could introduce a virtuous cycle: by making design processes and teams more inclusive, it serves as a strategy to help embed further design justice changes. These collaborations can support pathways forward with UN-SDGs in conjunction with design justice.

The analysis of summit materials revealed a dilemma among instructors: instructors wish to ensure that design justice-minded changes are well-thought out and meaningful, but there is a paralysis of analysis. This paralysis could risk bringing progress to design education to a standstill, and includes instructors’ concerns of embedding this content poorly or being unable to do this well. Overall, this could lead to inaction that is harmful, leaving things unchanged and reinforcing techno-social dualism and depoliticization of engineering (Leydens and Lucena, 2017b). It can also perpetuate an over attention to technology and prevent instructors and students from interrogating social structural forces and power imbalances present in engineering design contexts (Nieusma and Riley, 2010). Our results demonstrated that participants felt that these topics needed to be further incorporated into design education, also reflecting on how the field of engineering is still working on accepting design as a “rigorous area of engineering” (p12). This signals the critical need for cultural change in design education, especially engineering (Leydens and Lucena, 2017b; Burleson *et al.*, 2023), with plans to make space for design justice topics and space for instructors to learn together and build a community around bringing design justice into education. Resources and examples of embedding design justice can also help support instructors in this goal (Das, Ostrowski, *et al.*, 2023; Das, Roeder, *et al.*, 2023; Ostrowski *et al.*, 2023; Saadi *et al.*, 2023). As design education evolves, we must engage instructors in embedding equity, ethics, and justice into their courses and work with them to help provide a foundation for this change so instructors feel empowered to bring this material into their courses.

In addition to a clear desire to engage with and embed design justice into design courses, participants engaged in envisioning as a way forward to support them in implementing their plans for design justice in their courses and reflecting upon how best this could be done. Envisioning and futuring are powerful methods that support designers in considering how their designs will be implemented and also engaged with in the real world (Ballard, Chappell and Kennedy, 2019). Areas, such as speculative design and critical design, leverage envisioning as a powerful tool to navigate the intricacies of society, including social justice issues (Ballard, Chappell and Kennedy, 2019; Harrington and Dillahunt, 2021). Incorporating envisioning into the DJPS supported participants in being able to articulate a future where design justice is meaningfully embedded into design education, critique and reimagine existing design education structures, and reflect upon the necessary steps to attain these goals. The policy envisioning activity at the summit demarcated two different types of envisioning: blue-sky and realistic. The blue-sky envisioning supported a divergent idea generation space where there were no limits to participants' ideas that promoted them to consider the ideal future (Liu, Chakrabarti and Bligh, 2003). This aligns with the intent behind design tools, such as design fictions and methods cards, that foster this expansive type of envisioning (Harrington and Dillahunt, 2021). The blue-sky envisioning was paired with a subsequent realistic envisioning to help understand the barriers and limitations that instructors face when trying to reach their visions. Diversity and equitable access in university institutions and integrating design justice was a core part of many participants' blue-sky visions. While these topics were very common in blue-sky envisioning, they were less seen in realistic visions, as participants seemed to feel these goals were less achievable in the real world that they work within.

The tensions preventing these blue-sky visions included resistance to change, a barrier that is common for creating sustainable change in social justice spaces (Saadi *et al.*, 2023). Other barriers included incentivization and/or prioritization of design justice in university spaces and needing resources (Saadi *et al.*, 2023). These point to the need of a cultural shift within university spaces where we move from having little attention to design justice in design courses to having design justice considerations be embedded throughout the curriculum. To achieve this, it is critical for institutions to provide incentivization and prioritization for instructors to be given the time, space, resources, and encouragement to support design justice in design education. Instructors who do this well should also be recognized for how they have excelled in supporting training designers to critically engage with equity, ethics, and justice in design scenarios (Ostrowski *et al.*, 2023). Shifting the environment in this way can support instructors in engaging in change sustainably, where they will not feel burned-out or that their changes for equity and justice are not working or not valued by university contexts. Rather, community support and incentivization can help instructors feel empowered to continue to do work in this space and shift the culture. By supporting this shift of perspective and culture in design spaces, we can hope to move the blue-sky visions closer to the realistic visions, where participants feel they are empowered and supported to reach their blue-sky visions to maintain and support change in design education spaces.

The DJPS supported instructors in reflecting upon their courses, planning initial change, and envisioning the future of design justice in design education. It also realized this gap of what we want to do in the field versus what we think we can do realistically in our space. Participants' reflections and insight into their courses and design education, broadly, left us with the question of how do we bridge the gap between what we want to do and what we can do in our spaces and how do we make this change sustainable. Our results indicate four areas that can support sustainable change in design education: (1) documenting, (2) community, (3) resources, and (4) industry incentivization. Through implementing these changes, we can embed equity and justice into design education to help us move closer to realizing the UN-SDGs in educational spaces.

Change in academic spaces is often driven through **documentation**, including measurement and data. In 1999, a group of MIT women faculty members wrote a landmark report, titled "A Study on the Status of Women Faculty in Science", documenting inequities between women and men faculty members, including how women faculty members were treated differently and received unequal resources (First and Second Committees on Women Faculty in the School of Science, 1999; MIT Koch Institute, 2024). In addition to revealing inequities, this report drove policy change and nationally brought attention to this issue (MIT Koch Institute, 2024). Similarly, with design justice in design education, we can support embedding these considerations by collecting data on their effectiveness, the value gained, and the long-term impacts of this coursework. We can continue to document changes that support design justice, providing models and strategies for how to embed these topics successfully and collecting narratives of the impact of these methods in the classroom from multiple stakeholders in design education spaces, including instructors and students. Instructors can also work to develop measurement and assessment tools documenting the impacts of design justice interventions in design education. By providing this foundation of data, information, and narratives, we can provide documentation that supports design justice in design education to help drive sustainable long-lasting change.

The next way we can support sustainable change is **community**. Throughout the DJPS, community was identified as essential to support participants in incorporating design justice change. Community could include colleagues within an institution, organized groups such as the Summit participants, or organizations. Forming communities of like-minded scholars and practitioners can help instructors create change and be encouraged and advised by people also working in this space. Instructors can also join groups that exist around embedding design justice into educational spaces. Instructors can be involved in the Design Justice Network community by signing onto the [design justice principles](#) and becoming members of the network. They can also join the Design Justice Network's [Instructional Design Working Group](#) with members who are interested in embedding design justice in instructional design. This is just one example of a community that can support instructors in embedding design justice.

Resources have been identified as one of the most necessary components to support instructors in embedding design justice in their courses (Saadi *et al.*, 2023). Frameworks

such as design justice (Costanza-Chock, 2020) and Engineering for Social Justice (Leydens and Lucena, 2017a) operate as ways for instructors to embed these topics. There are also additional resources being developed such as case studies (e.g. [MIT Case Studies in Social and Ethical Responsibilities of Computing](#)) that engage with design justice-related topics or social and ethical responsibilities of designers. As the design education community is building these resources, instructors can support others interested in this space by making their materials open-source and available for use. For example, we are in the process of open sourcing the activities from the DJPS (interested parties should reach out to authors for more information).

Industry incentivization can increase sustainability of design justice in design education by continuing the emphasis of it in design practice. As design graduates are learning about equity, justice, and ethics in their coursework and valuing and centering sociotechnical dimensions of engineering design, they are looking for these considerations to be present in industry roles (Burleson *et al.*, 2023). Creating design positions in industry that engage with these areas will support design graduates who are interested in pursuing positions that support social good (Burleson *et al.*, 2023). This will support greater attention to design justice-related topics in industry and promote skill transfer around equity, ethics, and justice from design education to design practice. With additional industry incentivisation and a growing workforce dedicated to these considerations, we can further grow in our work addressing the UN-SDGs.

By working in these four areas, we can help bridge the gap between what we want to do (our ideal blue-sky vision) and what we can do (our realistic vision) and embed design justice in design education in a sustainable way to support our futures. Our case study demonstrates the opportunity for impact that a format, like the DJPS, can create. Additional studies can explore the long-term impact of these interventions and how they can reshape design education - we have already done some initial post-interviews with participants and would be interested in doing further longitudinal follow-ups with the DJPS attendees. Another area for future research is to understand how impact can be documented and measured (as highlighted in our key areas). Our work has limitations including that the DJPS was geographically located in Boston that could have prevented people from attending the event, leading to representation of mostly local universities. Future work can expand this work to other university contexts and make this a recurring event to understand how support may vary depending on geography and time.

Conclusion

This paper explored how the DJPS provided scaffolding for instructors to embed design justice into design courses through three main activities: the initial step workshop, syllabus “makeathon”, and policy envisioning session. The activities were designed to support instructors in reflecting upon their courses, reimagining how they could incorporate design justice, and envisioning the future of design education with design justice concepts sustainably integrated. Our results demonstrated that participants reflected upon the importance of design justice and embedded it into their courses in

multiple ways. Participants also noted the importance of colleague and institutional support when implementing change in their workplaces. Overall, to incorporate design justice in design education in a sustainable manner, it is critical for change and support in four main areas, including documenting successful implementations of design justice, fostering communities of support, building resources for instructors to learn from and incorporate into their courses, and shifting industry emphasis to value design justice. Through reflecting upon and reimagining spaces that value design justice, we can reshape institutions for sustainable design education that will evolve how communities address the UN-SDGs, creating greater equity and quality of life for all.

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Living-Centered Design: Embracing Collaboration and Co-Creation with Nature for a Sustainable Future

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ABSTRACT

The present paper explores the paradigm shift in the Design Process towards a more sustainable and interconnected approach. It has evolved to envision and prepare for future challenges and opportunities, namely, the UN's Agenda 2030, advocating for a transformative design ethos beyond anthropocentrism. The expertise and characteristics of this new designer are intrinsically related to the "designerly way of knowing." It is a human-centered approach that strongly emphasizes collaboration and co-creation, requiring the designer's ability to anticipate changes, forecast and plan, prototype, and iterative testing. However, this research focuses on the significance of collaboration and co-creation as a design attitude, promoting a participatory, engaging approach involving all living beings. Therefore, it claims not to be a Human-Centered Design (HCD) but rather a Living-Centered Design (LCD), a co-design process done with other humans and non-human beings. When redefining this new relationship between designers and other living entities, shifting to learning and co-creation with Nature is essential. Therefore, we explored indigenous knowledge and nature's symbiotic relationship to understand how to transform resilient and sustainable design practices, evolving into a mutually beneficial partnership. We delved into interdisciplinary collaboration, knowledge-sharing, and integration, highlighting the benefits of collaborative design processes. Moreover, we proposed a 'living together' approach, where designers and non-human beings mutually benefit from each other, fostering a harmonious and interconnected coexistence. Examples of collaboration with living organisms such as bees, fungi, bacteria, algae, and plants were presented, drawing insights from biomimicry and Growing Design. They illustrate how designers can work alongside Nature without causing harm, reimagining the production of consumer goods more sustainably. In conclusion, the journey towards Living-Centered Design invited us to recognize and embrace other living organisms' intelligence and productive abilities, offering a transformative approach to design that goes beyond anthropocentric boundaries. This approach is vitally crucial for a Design Centered on Life and the complex challenges of our era. By embracing collaboration and co-creation with Nature, designers will pave the way for a more sustainable and harmonious future for all living beings on Earth.

Keywords: Sustainable Design, Living-Centered Design, Collaboration, Co-creation.

Introduction

Design Process relates to applying principles and methodologies to envision and create solutions for future challenges, opportunities, and scenarios. It is a Human-Centered approach to problem-solving that emphasizes empathy, creativity, collaboration, and iteration (Vasconcelos, 2023). It involves understanding people's needs, generating innovative ideas, prototyping, and testing solutions. However, what are the main characteristics of a future designer who faces complex systemic changes and needs to reduce negative impacts on our environment? Is there a "designerly way of knowing," as stated by Nigel Cross in 1982?

After immersing in a systematic literature review about designers' skills (Lawson, 2004; Lewis & Bonollo, 2002; Koh et al., 2015, to name a few), their core principles should include:

Human-Centered Approach: There is a strong emphasis on understanding and empathizing with users. This approach concerns conducting research, interviews, and observations to gain insights into people's values, behaviors, and aspirations.

Designing Change: Understanding emerging disruptions, trends, and shifts shaping the future. It aims to design the change in technology, society, culture, and the environment that activates the design process.

Foresight and Scenario Planning: incorporating methods to imagine and explore different personas and scenarios, identifying potential challenges and opportunities.

Iterative Prototyping and Testing: Exploring various possibilities and iterations in response to future challenges, refining and improving designs over time.

Collaboration and Co-creation: An intrinsic interdisciplinary collaboration and co-creation basis brings experts from diverse fields to combine perspectives and expertise in generating innovative solutions.

In this paper, we explored Collaboration and Co-creation by understanding it as a *design w/ attitude*, a participatory, collaborative, and engaging approach with all living beings. This focus on the ideas brought by Sennett (2012) in the book "Together: The Rituals, Pleasures, and Politics of Cooperation" aligned with the ideas from "Design with Nature" by Ian McHarg (1969). Our hypothesis is that learning to collaborate and co-create with Nature should be the main attribute of creating resilient, sustainable, and Living-Centered Design in an ever-evolving world. Therefore, two questions were included: What is the critical significance of embracing a Living-Centric Design approach for addressing contemporary challenges, and how does the imperative for collaboration and co-creation with Nature contribute to its essentiality?

Methodology

A Systematic Literature Review established the conceptual foundation for this study to support our data collection, synthesis, reporting, and search efforts to address our

research goals. The Scoping Review was also chosen because it facilitates the systematic and iterative process of knowledge synthesis, finding, and building a body of literature. Figure 1 shows the designer's skills needed for a more sustainable world creation and related to the "designerly way of knowing" after selecting 27 papers and using the keywords Designer Knowledge, Design Expertise, and 21st-Century Design Skills.

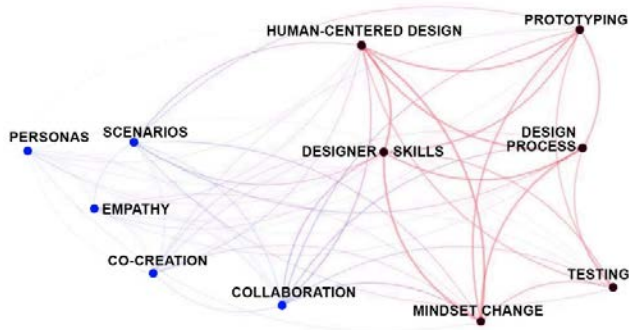


Figure 1. VOSviewer network visualization map with the first concept results.

We repeated the methodology, changing the keywords to Co-Design, Sustainable Design, Designing with, Collaboration, and Co-creation with Nature. In order to establish the articles' relevancy, we carefully reviewed the retained papers, eliminating duplicates and using a time criterion (from the year 2001) to get this century's concepts. We also screened the articles' titles, abstracts, and keywords. Moreover, snowballing was necessary to track citations across different sources. This second bibliometric network was constructed with 50 selected articles (Fig. 2)

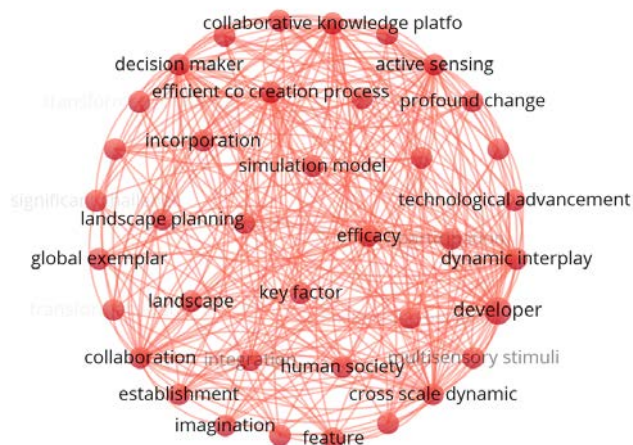


Figure 2. VOSviewer network visualization map with the second concept results.

Case studies were also valuable for many reasons, including 1. Outlining the consequences of a theory, 2. Investigating new fields and problems with sparse

theoretical support; and 3. Clarifying a complex phenomenon. Despite the traditional identification of this approach with exploratory purposes, Khon (1997) contends that its intrinsic ability to address the subtleties of how and why situations develop accounts for its effectiveness in explaining the causes.

Literature review and examples

Designing w/ - part 1 (humans and humans)

The reflection on the subject of the designer's work has been extensively explored and supported by prominent authors in the field (Dorfles, 1991; Bonsiepe, 1992; Maldonado, 1993; Hemming et al., 1996; Burdek, 1999; Cross, 2003; Munari, 2004; Lawson & Dorst, 2009). Accordingly, it is widely acknowledged that the designer's work is not autonomous, and the objectives outlined aim to promote the solution of complex problems considering the capacity for collaboration and dialogue.

To collaborate means to cooperate, to help, to assist. It comes from the Latin word *collabore*, and its etymology shows its meaning: *con- + laboro*, that is, to work together, participate, and get involved. Collaborate is an indirect transitive verb. It needs a complement to make sense, an obligatory preposition: working together with others.

Richard Sennett (2012) praises cooperation in his book "Together: The Rituals, Pleasures, and Politics of Cooperation" (2012). He explains that it "emerges as a skill, that is, an ability to understand and be receptive to the other; a way to achieve a joint end" (p.10). Together, we act, and by doing so, there is a broadening and deepening sense of community, recognizing and respecting diversity and multiculturalism.

Gui Bonsiepe (2012) defines alterity as an assumption or "willingness to respect other project cultures with their inherent values" (p.38). It is a concept that breaks with the dichotomy of both developed and underdeveloped. The proposal is to look at, understand, and measure the impact of the other in a bilateral and interpersonal partnership relation interpersonal relationship (designer and partner). It eliminates counterpoints such as domination and submission, superiority and inferiority, heteronomy, colonialism, universal standards, exclusion, and welfare. It is essential to work on and validate the concepts of collaboration, autonomy, respect, trust, emancipation, motivation, and empowerment.

When working, the actors (designers and stakeholders) exchange knowledge, information, and experiences, creating new knowledge, processes, products, services, and worlds. As exposed by Hassi and Rekonen, the starting point of interdisciplinary collaboration is "information asymmetry, which means that team members have different and not shared information" (2018). Doing so exposes the following relationships:

intra-individual (which considers the history, memories, emotions, experiences, existing and attributed meanings, and all the personal load brought by each actor to the meeting);

situational (which presents these individuals as a result of the context and locality in which they are inserted);

ideological (which presents the collective beliefs and values, the existing culture, and the similarities/differences between the different points of view); and, above all, the

positional (in which the individual's position in the network of social relations is considered) (Paoliello, 2020, p.46).

The intra-individual relationships bring the burden of each person evolving with their particularities, specific knowledge, area of expertise, and skills. The situational ones present personal identities resulting from culture and territory. In contrast, the ideological ones carry the different visions of the world, the individual system of thought, and the political-social construction of each actor. Finally, the positional establishes the designer-other professional relationship.

Designing with plays a pivotal role in fostering shared experiences, co-producing knowledge, and nurturing interconnectedness among individuals, emphasizing connections, understanding, and solidarity. However, tensions and contradictions may also arise within these practices. Embracing these divergences and embracing pluriversal perspectives (Escobar, 2018) demands continuous learning. It is a conscious effort to transcend hierarchical dynamics and move beyond individualistic approaches to a more inclusive and equitable coexistence.

Pol (2002), Vidal and Pol (2005), and Valera and Pol (1994) contend that the realization of a sustainable society hinges upon its foundation as a socially structured, democratic entity that actively employs participatory processes. Another question arises if it is a skill so important to a future sustainable society: How can someone learn how to collaborate? Kleinsmann et al. (2012), in the paper *Development of Design Collaboration Skills*, explore how design collaboration skills develop along with design expertise.

For these authors, Collaborative Design is a "knowledge-sharing and knowledge-integration process" (Kleinsmann et al., 2012, p.486). They align with McDonnell's (2009) perspective: knowledge sharing occurs during turn-taking conversations, with each person contributing expertise from their respective areas. As the dialogue continues, information is supplied, leading to knowledge integration - a collaborative process aligning individual knowledge bases to establish shared orientation within the others. This knowledge-sharing and integration concept is applied to assess collaborative design performance.

It is a process of collective cognition, as Gibson defines it (2001, pp. 122-123). This concept involves the accumulation, interaction, examination, and accommodation of multiple (intra- and extra-individual) information, as in Fig. 3.

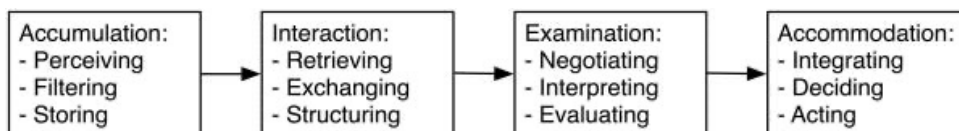


Figure 3. Phases that comprise collective cognition (adapted from Gibson, 2001).

Finally, it encompasses developing essential social skills, including conflict resolution, role and responsibility negotiation, and relationship management (Lauche, 2007), which are essential to cultivating a sustainable attitude, at least partially.

Before the next section, it was crucial to understand that all living organisms have seven characteristics in common: environmental response, fundamental units, change and growth, reproduction, complex chemistry, maintaining homeostasis, and energy processing (Jones & Jones, 2014). Moreover, that “if artifacts possess livingness as a quality, they will have the unique ability to grow, metabolize, respond to external stimuli, reproduce, move and respire, and, ultimately, adapt to their environment” (Karana, E.; Barati, B.; Giaccardi, E., 2020, p.40). Those characteristics are based on a meticulous play of forces between coadaptation and coevolution, “coadaptation (fitting together) is a consequence of coevolution (changing together)” (Marten, 2001, p. 61). That is the reason speculating part 2 - *Designing w/* humans and non-humans will contribute to the Living-Centered Design emerging body of work.

***Designing w/* - part 2 (humans and non-humans)**

Conventional methods of promoting sustainability awareness have typically focused on disseminating information regarding environmental issues, policies, and technologies. Nevertheless, this approach somehow ignores the humanistic, human-human, charity-compassion trait of it all. Nonetheless, emerging research indicates that achieving enduring change demands a more profound transformation in our approach.

Several authors are forging a reconnection between Biology and Design, advocating for integrating Nature-inspired strategies to address the critical challenges of this era. Janine Benyus, author of the renowned book *Biomimicry: Innovation Inspired by Nature* (1997), has defined biomimicry as the “conscious emulation of life’s genius.” She stated that the focus should be on understanding, learning from, and emulating the strategies used by living things to create Sustainable Design and technologies. The questions that arise are: How can a Nature language be developed? How can we learn to collaborate with a non-human living being?

The first suggestion is developing environmental awareness, that is, understanding the impact of individual actions and choices on the environment and ecosystems as essential for adopting sustainable practices. Recognizing the interconnectedness of social, economic, and environmental systems is also essential and a step toward developing empathy toward others, including not only (human) future generations but Nature (non-human beings) itself. There is a switch from learning about Nature to learning from

Nature. By doing so, the *flora*, *fauna*, and *fungi* species (Fig. 4) are transformed from objects to subjects and from resources to teachers.

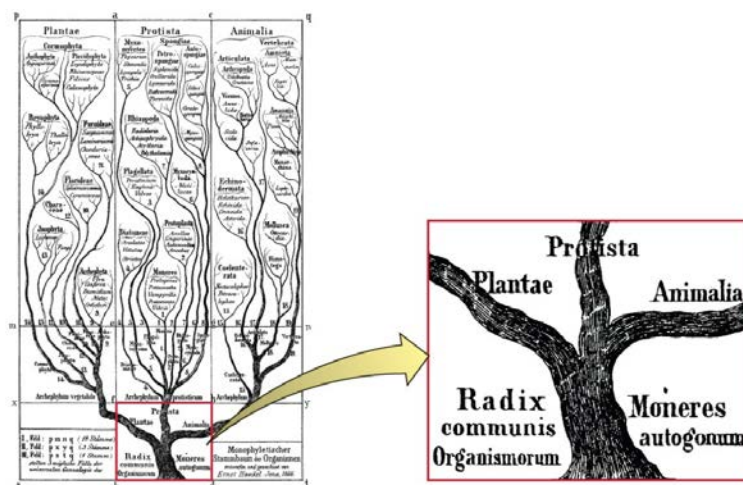


Figure 4. Haeckel's original (1866) conception of the three kingdoms of life.

The characteristics of openness, trust, and respect for co-creation, as described in part 1, remain fundamental. The difference now is that collaboration will occur between two or more individuals who do not speak the same language but manage to coordinate their behavior to produce outcomes that bring expected benefits. Nevertheless, does collaboration play an exceptional role only in humans (*Homo sapiens*)? According to Duguid and Melis (2020), other species also achieve collaboration. To these authors, interdependence and the need to work together significantly contribute to human cognitive evolution and other non-human beings (Duguid & Melis, 2020, p.2). They illustrate their hypothesis using Boesch and Boesch's (1989) studies. These two authors have outlined the group hunting behavior of chimpanzees, categorizing it into four progressively intricate behavioral domains: similarity, synchrony, coordination, and collaboration. This last skill, which this paper mainly focuses on, is described as the most complex category to be perceived. Boesch and Boesch (1989) defined it as "hunters performing complementary actions, all directed toward the same prey."

Achieve collaboration requires the consideration of both the actions and perspectives of others and also intentional coordination, that is, a "collaboration based on shared intentionality, which involves the full set of cognitive and motivational mechanisms typical of adult humans engaging in true team tasks" (Duguid & Melis, 2020, p.3). However, it could also be classified as an actively coordinated collaboration. Being able to wait for a partner and recognizing when he/she is needed has demonstrated collaboration skills versus solo apparatuses (Duguid & Melis, 2020, p.6). Through close complicity with various species, designers need to learn a new vocabulary that enables them to comprehend Nature's expertise and gain autonomy in envisioning the potential of biotechnology for design practices.

Bjögvinsson, Ehn, and Hillgren (2012, p.102) argued that "a fundamental challenge for designers and the design community is to move from designing "things" (objects) to designing Things (socio-material assemblies)." Along with this challenge is the design with stakeholders when they are non-human beings.

That was Tomitsch et al.'s (2021) article that assesses how the personas method could be adapted to include more-than-human species (animals and plants), ecosystems and their perspectives in the Design Process. They stated that "the non-human personas proved successful at prompting and supporting expert participants with critiquing a design proposal through the lens of non-human stakeholders. From the designer's perspective, the non-human personas served as a reminder to keep the issues of non-human species in mind when making design decisions." (Tomitsch et al., 2021, p.112).

South American indigenous communities, emphasizing harmonious coexistence with their surrounding natural systems, offer alternative knowledge-making approaches that diverge from the prevailing anthropocentric perspective prevalent in modern science.

The big difference in the Indians' way of thinking is that the white people understand the environment as a 'natural resource,' as if it is a warehouse where we go and remove things endlessly. For the Indigenous people, "the environment is a place to step on gently and cautiously because it is full of other presences," as said by Ailton Krenak (2015) in the launch of his book "Encontros - Ailton Krenak" and available at <https://www.youtube.com/watch?v=JizR5UOm4uw&feature=youtu.be>

He clarified that the previous generations' memories rely on a natural territory and are needed for the future, as similarly stated in the famous Brundtland Report "Our Common Future." Expanding its meaning to this 'new interdependence era' invites different living forms to be together. This "living together" refers to symbiosis, a term coined by Albert Bernhard Frank in 1877 to describe the mutualistic relationship in lichens. It can be classified as *mutualism*, when all partners benefit; *commensalism*, when one benefits and the others continue to live unharmed; or *parasitism*, when one benefits but the other is harmed (Wilkinson, 2001).

The Biodesign approach is a fascinating opportunity for collaborative creation with Nature, reimagining the production paradigms by bridging Biology with Art, Architecture, and Design (Antonelli, 2012). Moreover, it helps change the way humans relate to Nature. In all Biodesign products, humans guide and drive the growth of other organisms, and almost all of them rely on a parasitic relationship.

Is there a way to change this scenario? Could these symbiotic interactions substantiate the collaborative process in which designers and living beings mutually benefit from each other? Could both "organisms collaborate as active and sentient agents of the creative process, offering their intelligence and productive abilities" as described by Camere & Karana (2017, p.111)?

Collet (2013), in "Alive: New Design Frontiers," grouped 34 projects under five categories based on their possible relationships with Nature (Fig. 5): 1) Nature as a model

(referring to designers as "The Plagiarists"); 2) Nature as co-worker in Design Process ("The New Artisans"); 3) Nature as reprogrammed and synthetic ("The BioHackers"); 4) Nature as hybridized with non-living technologies ("The New Alchemists"); 5) Nature as conceptualized and imagined in a provocative far future ("The Agents Provocateur").

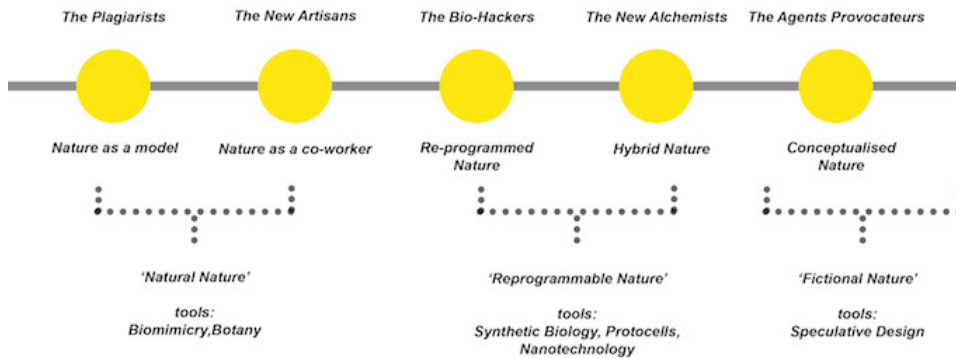


Figure 5. Biodesign: From Biomimicry to Biofacture: Five strategies for designing with the living by Collet, 2013.

In the second group, Nature as a co-worker, the designers collaborated with Nature (Fig. 6) when they worked with bees (Vessel #1 by Tomáš Libertíny), fungi (Yamanaka Furniture by Philip Ross), or plants (Biophotovoltaic Moss Table by Carlos Peralta, Alex Driver, and Paolo Bombelli). They develop new techniques to grow and craft consumer goods without killing the other living partner, rethinking the artifacts' production in a more efficient/sustainable way.



Figure 6. Nature as a co-worker examples: Vessel #1; Yamanaka Furniture; Biophotovoltaic Moss Table. From: <http://thisisalive.com/exhibits/>

They are examples of 'Growing Design' defined as the fabrication of materials and products from living organisms (Camere & Karana, 2017, p.101). It is a design approach that is more related to gardening and farming than manufacturing. Their practical and methodological challenges used sustainability-related premises and the possibility for

unique design expressions when designing with or collaborating with living organisms. As in a Collaborative Design, it depends on the relationships exposed in part 1 (intra-individual, situational, ideological, and positional relations) on the symbiotic interactions and the technological and economic opportunities alongside its ecological benefits.

These examples also outline Veselova and Gaziulusoy's (2019) and Rice's (2018) considerations for Nature-Inclusive Collaborative and Participatory Design, outlining the benefits of involving humans and non-humans in the Design Process titled Bioinclusive Ethical Approach.

Drafting a conclusion

It is time to go back to the main research questions: What is the critical significance of embracing a Living-Centric Design approach for addressing contemporary challenges, and how does the imperative for collaboration and co-creation with Nature contribute to its essentiality?

By embracing a Living-Centered Design approach, humans will live, engage, and cohabit with living artifacts. According to this research, the scenario where living organisms (humans and non-humans) cooperate will help achieve sustainable coexistence. It will need careful cohabitation, intra- and interspecies interaction, and a well-established relationship with other non-living beings, which are necessary to create a perfect ecosystem. While humans will continue to benefit from living artifacts' presence, a novel approach to co-creation is envisioned - one that will always emphasize non-hierarchical alliances, symbiotic connections, and the convergence of creative agents, encompassing both human and non-human agents and, therefore, pave the way for a more sustainable and harmonious future for all living beings on Earth.

This era heralds the emergence of collaborative and co-creative practices that foster the development of resilient, sustainable, and Living-Centered Design.

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From Empathetic to Reflective Dialogue: A Visual Tool for Future Social Design Education

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ABSTRACT

The UN 17 Sustainable Goals have influenced thinkers and practitioners for years. Their influence is extremely important to social design, especially those dealing with community involvement, quality education and reduced inequalities. These principles resonate with a key pedagogic approach titled SEL (social and emotional learning) and PD (participatory design). As these value-oriented approaches start with empathy to the other, we believe we need to integrate them while teaching future designers in the classroom and the studio. We offer a visual tool for reflective visual dialogue in social design education and practice meant to facilitate the communication of situated knowledges between various design partners. We do so through two main venues: first, from the learner's point of view, we use our tool to instigate and trigger a process of self-reflection and personal definition, on individual and professional levels. Conversely, this tool can help students in the classroom find suitable partners to work with for the duration of the course (either complimentary or similar potential partners). Second, from the educator's point of view, we use the tool for several goals: mapping the students in the classroom according to various attributes; managing the progress of the class in general, according to personal efficiencies; and using the mapping to generate richer and more diverse outcomes at the end of the course. We will also delve into the advantages of developing this type of knowledge through visual representation tools, triggered through visual communication. Finally, this approach will highly benefit designers embedded in working with communities through strategies of participatory design, due to its dialogue nature.

Keywords: empathy, participatory design, dialogue, design education, visual mapping.

Introduction

Care has been a companion to the social venues of design practice in the last decade, as has empathy. From "Designing for your Future Self" to the "Does Design Care" initiative, designers invested time and energy to reach practical solutions to situations previously untouched by designers. Design for dementia, design and ageing, both apparent in the UK, followed the then-established premise of inclusive design which focused primarily

on the designing for the social margins or extremes, generally ignored by mass-production solutions. These important design strategies revolved around the dialogue between design practice and empathy and the care for an imagined “other” (which in most cases can and might eventually be us). It is not our intent to delve into the history of care in design, however, we wish to start from that important stepping stone and offer an adjacent venue through which we will illustrate the importance of a care-centered design in the classroom, vis-a-vis the significant local and global challenges we face as design practitioners and educators. We believe that to create an inclusive classroom that helps forward humanistic and pluralistic agendas, visual mapping and visual representation can become a key element in social design education in particular and design education in general.

Let us return to the issue of empathy. While the key design strategies we are based on - primarily, inclusive design, social design, and participatory design - are deeply embedded in the notions of empathy and care, the former need a short introduction due to its common use. In its most simplistic meaning, empathy (etymologically stemming from “pathos”) typically means the ability to share another person’s feelings. Yet, this seemingly obvious definition holds various ethical, philosophical and psychological questions, ranging from the ability to not only understand and adopt another person’s perspective but also to (mis)interpret their intention, as well as an intricate system of socio-cultural interpretation. Indeed, the Stanford Encyclopedia of Philosophy highlights the connection between empathy and aesthetics as a tool to imbue the observer with said pathos. However, it is its connection to phenomenological theories that interests us due to the crucial connection between design and emotion, feelings and memories, in its journey to create meaningful experiences (Devecchi and Guerrini, 2017). Naturally, as a discipline that offers practice-based solutions in real life, design needs to consider this notion, as it has in the last decade, at least in its socially oriented sub-disciplines. Moreover, as in the early 1980s Cross (1982) highlighted the innate ability of design to empathise as part of its practice. Historically, mass production, as part of the industrial revolution, created a chasm between the end-user’s needs and constraints and the actual design and manufacture of the product. After both World Wars, preliminary efforts such as Dreyfuss’ *Designing for People* (1955) returned the designer’s gaze to their original focus - the users. Naturally, while from a psychological perspective, empathy holds various dimensions and leads to relevant treatment, from a design perspective two of these stand out. Affective Empathy refers to the capacity to appropriately respond to another’s mental state, while Cognitive Empathy, to the ability to know and understand another’s perspective (see Davis, 1994; and Batson, 2009). Indeed, in social or healthcare design, these perspectives are crucial not only in the process of research but also in the mental shift needed by designers, as well as design partners and other stakeholders. A key problem in the relationship between empathy and design lies in its origins in consumer-oriented agendas coupled with design thinking in the late 1990s (Devecchi and Guerrini, 2017). Due to its market-oriented approach, this dialogue started from a skewed angle due to the necessity to focus on the market’s needs.

However, as the aforementioned socially-oriented approaches took hold of the concept of empathy it found a new course and interpretation as well. Lately, Heylighen and Dong (2019: 112) ascertained that

In this sense, it is perhaps more accurate to state that empathy is oriented to the other's situation, as opposed to your own situation, rather than empathy being oriented to the other as opposed to yourself. Indeed, in order for your (un)happiness to be genuinely empathetic, it has to be (un)happiness about what makes the other (un)happy, not (un)happiness about the other being (un)happy.

From a practice-based approach, among the leaders in this new path, we can find Manzini (2015; 2016) who addresses the importance of empathy to create social innovation, not only from a practical perspective but also from an educational one. Indeed, Heylighen and Dong (2019), identify several venues in which designers have been encouraged to develop their empathy in the last two decades (and especially in the social spheres of design practice) - through research, intrinsic and extrinsic communication in the design team, and diverse ideation techniques. Manzini (2016: 58) follows this trail adding the notion of 'dialogic design' which might be described as

It is a social conversation in which everybody is allowed to bring ideas and take action, even though these ideas and actions could, at times, generate problems and tensions. As a result, what makes a dialogic conversation in a design process is that the involved actors are willing and able to listen to each other, to change their minds, and to converge toward a common view; in this way, some practical outcomes can be collaboratively obtained. In short, these involved actors are willing and able to establish a dialogic cooperation—a conversation in which listening is as important as speaking. It comes that, in the dialogic design framework, the design experts' capability to listen is a crucial one.

Also, sociologist Sennett (2021:18) adds that dialogic conversations are more open-ended, less competitive, open for ambiguity, contain implicit knowledge and therefore are more suitable for facilitating cooperation. Interestingly, as early as 1997, Leonard and Rayport called for the integration of empathic design not only as a tool for innovation, but also to entail "techniques (that) require unusual collaborative skills, open-mindedness, observational skills, and curiosity." As our own implementation of what we call "reflective dialogue" we call for an intrinsic as well as extrinsic communication through the frame of a visual dialogue. Through their own situated knowledges, design students learn not only to harness the potential of a heterogeneous thinktank, but also to conduct complex dialogic interactions with various stakeholders in their practice.

Design-based competencies & the UN goals

As we have seen, the ability to engage in an empathetic and critical dialogue is a crucial skill for contemporary and future designers, including our students and ourselves, as educators, researchers and practitioners. Advanced knowledge of this skillset enhances the quality of design teaching and education, aligning with UN Goal 4. Discussing individual identity parameters, along with associated privileges and non-privileges

therein, exposes inequalities among classroom participants, supporting UN Goal 10. How each team addresses these is a matter of choice and context. Nevertheless, the visual tool we will present facilitates discussions about diverse living and working conditions, which are essential for the future skillset of designers, especially when working within local community contexts. In the near future, the visual tool will also bring external stakeholders of the design project into consideration: local communities, NGOs, local governments, or small-medium enterprises. In this case, UN goal 11 puts the debate into the situated framing of sustainable cities and communities. With this broader perspective we can also aim for shifting empathy towards your own environment with all living beings comes into play (beyond-human design, multispecies design, planetary design, etc.).

Three existing frameworks may help achieve the UN goals we have discussed. First, inspired by the universal design approach in architecture and design, the Universal Design for Learning (UDL) presents a set of principles that equips educators to meet the diverse needs of all learners. This approach is highly relevant for ensuring inclusive and equitable quality education (UN goal 4) and reducing inequalities within the classroom environment and between group members (UN goal 10). Defined initially by David H. Rose of the Harvard Graduate School of Education and the Centre for Applied Special Technology (CAST) in the 1990s, the UDL framework advocates for a curriculum that offers: multiple means of *representation* (providing learners various ways to acquire information and knowledge), multiple means of *expression* (offering learners alternatives to demonstrate their knowledge), and multiple means of *engagement* (UDL aims to broaden learning access by minimizing barriers, whether physical, cognitive, intellectual, or organizational). Applying UDL principles in Higher Education Institutions (HEIs) ensures that educational materials and environments cater to the needs of students with diverse characteristics. In social design education, we aim to foster a diversity of student contributions, leading to varied design outcomes in their practice. Consequently, we are particularly cautious about relying on assumptions rooted in traditional education models. The tool presented here emphasizes visual and collaborative characteristics, drawing on knowledge transfer practices in the context of co-design, active learning, converting implicit knowledge to explicit knowledge, collaborative knowledge construction, and learning-by-doing.

Second, Social and Emotional Learning (SEL) skills have increasingly been recognized as crucial components of education at all levels, to support students' overall well-being and academic success. One of the most well-known SEL frameworks is the model provided by the Collaborative for Academic, Social, and Emotional Learning (CASEL). This framework includes five components: self-awareness, self-management, responsible decision making, social awareness, and relationship skills. Research shows that SEL-based competencies are key to implementing the SDGs; Asah and Chatterjee Singh (2019) argue that the SDGs are not necessarily a set of consistent objectives but rather a series of potentially conflicting goals. The dissonance of this conflict may be managed through the adaptation of SEL-based competencies - mainly emotional resilience and

prosocial behaviour. Recent years have brought significant challenges to design education, including the prolonged COVID-19 pandemic and the current war in the Middle East. These events underscore the need to shift from merely acting as 'knowledge mediators' to (re-)embracing our roles as educators. Achieving this requires the implementation of emotional strategies in higher education, necessitating a reframing of both pedagogic and applied strategies, by that also supporting intentions of UN goal 4.

Third, in the context of social design, when considerations are situated in unsustainable, fossil fuel environments, the actors and communities affected by these challenges need to be considered within potentially transformative change processes. One of the most proven approaches to integrate these actors and communities into design processes, is the Participatory Design (PD) paradigm. Participatory Design is able to integrate those who are affected by current, mostly unsustainable developments, by offering a set of methods to empathetically give a voice to the ones often unheard or deliberately ignored. Also, to the ones being affected by decisions, but not having a say in it, which was already criticized by Arnstein in 1969. Robertson and Simonsen (2013) claimed that the "opportunity to influence" the decision-making process is a "basic human right" (p.6). To decide about our own living environment, our visual-material daily lives, or the data we produce through technologies, should always be the *by default* process, but in reality, it is not. Therefore, many critical design communities deal with these issues. For example, the *Design Educators Unite!* Initiative deals with the political dimension of design education and works together on approaches aimed at diversifying design knowledges and expanding the perspectives beyond "Western, white, privileged, cisgender and able-bodied" (<https://futuress.org/learning/design-educators-unite/>, last view February 12, 2024). Connected to these very important and needed paradigm shifts in the design research community, a stronger debate about privileges and non-privileges is needed. Goodwill not only offered a Power Literacy guide (2020) but also a theoretical framework (Goodwill et. al., 2021) on how designers are able to deal with power issues. They do so not solely within a design team; it is important to reflect whether different living conditions are represented in the team or not. This reflection is also connected to the realization that privileges are represented in the team, and others are not – and how to actively deal with it. Following this much-needed step, the second important consideration within the design team is how to plan the participation process during the design project: What participatory perspectives are missing on the topic addressed? How can important perspectives be integrated? How can those affected by the topic be selected? And how to deal with the fact that there may be overlapping forms of discrimination among involved people, which make every individual lifeworld a different case (cf. Czollek et al. 2019)?

Both of these steps are crucial for design teams and also for design projects initiated in higher education. Therefore, for us it is crucial to provide a tool to reflect individually, but also critically in the constellation of a team. The tool is a starting point for discussions but can also be used for reflection at various points during the semester or even at different reflective points in time within your study path. It helps to give time

and space for essential reflection in the teaching unit in the classroom, which is otherwise often lost due to time pressure.

To support the achievement of UN Goals 4 and 10, introducing a reflective dialogue approach into social design education classrooms is crucial. The need to introduce new forms of conversations, perspectives, and dialogues requires new and innovative facilitation tools. This paper introduces a visual and collaborative tool designed to facilitate personal reflections and plural conversations within classroom settings. Through our exploration of Universal Design for Learning (UDL), Social and Emotional Learning (SEL), and Participatory Design (PD) principles, we pose a question: how can collaborative visual tools effect and enhance empathetic and critical abilities, mainly creating and maintaining fruitful dialogues between different design partners and stakeholders?

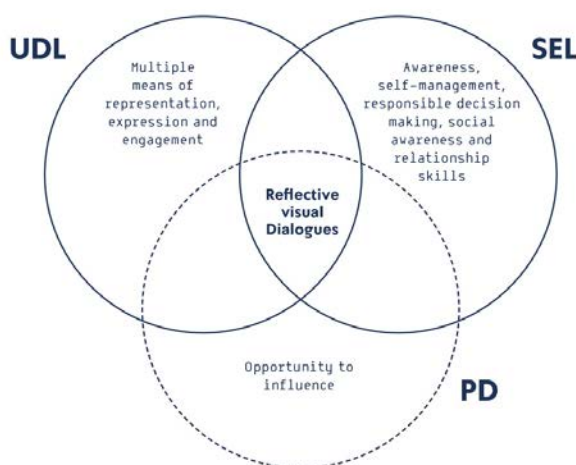


Figure 1. Summary of intertwined frameworks. UDL and SEL are incorporated into the first development stage of the tool, while PD will be fully integrated during a later stage.

Designing for reflective visual dialogues in the classroom

In this section, we introduce a new tool to integrate a "reflective dialogue" approach into social design education. The tool offers a systematic and holistic framework through the dynamic interplay of two main correlating and entangled type of actors: 1) the designer-educator, characterized by a set of educational values, personal identity, and professional preferences, and 2) the learners-novices, who bring their own educational backgrounds, professional aspirations, personal attributes, societal identities, and expectations. The tool is meant to be adapted in the future to include community members with whom we work, who manifest their own identities, desired outcomes, and socio-cultural context and relations.

Our design approach is based on visualization projects from recent years such as those by designers Giorgia Lupi and Stefanie Posavec in the "Dear Data" project (2016). Over fifty-two weeks, Lupi and Posavec collected, communicated, and exchanged data about their lives using hand-drawn data postcards, an action that became a kind of ritual:

We prefer to approach data in a slower, more analogue way. We've always conceived Dear Data as a "personal documentary" rather than a quantified-self project which is a subtle – but important – distinction. Instead of using data just to become more efficient, we argue we can use data to become more humane and to connect with ourselves and others at a deeper level.

They used data collection to better understand human nature and as an expressive medium through which they communicated their findings. In an article published in *Print Magazine* (2017), Lupi introduced the term '*Data Humanism*', a set of values that create a counter-movement to our addiction to automated data collection. Lupi's innovation is expressed not only in the type of information collected but also, and especially, in the way it is collected - the use of active and manual actions that reveal the processes. Revisiting the concept of 'reflective visual dialogue,' it becomes clear that the visual and interactive approach is highly important not only for personal engagement with the questions asked, but also as a foundation for dialogic conversations. This aligns with Yee's (2012) categorization of the use of visualizations in design, which she identifies as serving multiple purposes: "for reflection and exploration, as a tool for analysis and knowledge generation, and as a means for communication, facilitation, and discussion".

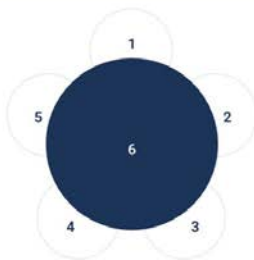
In our tool, each actor is presented by a flower-shaped diagram. Each diagram consists of five outer circles that represent five facet groups. These can be chosen by the education team before the beginning of the course, or be identified with the students in a participatory-design approach. For students, these facets might include gender, cultural group, disciplinary background, goals and expectations, and core values. The inner circle represents resilience tendencies - it is the only constant facet. The aspect of resilience was added inline with Asah and Chatterjee Singh's (2019) argument that look at the SDGs as a series of potentially conflicting goals that may be managed through the adaptation of resilience. Each facet, represented by a few attributes, offers a nuanced view, with some attributes visually intersecting with others. Both facets and attributes are adaptable based on the course's context, the students' backgrounds, and the situation - the project at hand. Fig. 2 presents an example of facets and attributes from one of our courses.

Lerner's facet groups and attributes

1	Gender	Female	Male	Non-Binary	Fluid		
							
2	Cultural Group	Jewish	Muslim	Christian	Undefined	Religious	Secular
							
3	Main Discipline/Background	Visual	Product	Digital	Fashion	Other	Multi
							
4	Professional Expectations	Signs and Symbols	3D Objects	Services	Systems		
							
5	Core Values	Commercial	Participatory	Glocal	Ecological	Critical/Speculative	Degree of Influence
							
6	Resilience Tendencies	Physical	Cognitive	Emotional	Meaning	Degree of Influence	
							

Structure

1. Gender
2. Cultural Group
3. Main Discipline
4. Goals and Expectations
5. Core Values
6. Resilience Tendencies



Example



Figure 2. Learner's legend, structure and an example of use.

The tool is introduced to students at the beginning of the course, followed by a detailed presentation of the visual structure, emphasizing each facet group and its attributes. Following this, students gain access to an online board designed for the individual mapping activity. For the mapping activities, we used the Miro collaborative online platform, chosen for its user-friendly features. Within the Miro board, each student is provided with a designated canvas (or 'frame') to construct their diagram. After completing the individual mapping, students are invited to engage in group discussions to foster conversations and provide feedback through a questionnaire. The process begins with individual activities that transition into a group activity, enabling students to gradually process and analyze their knowledge.

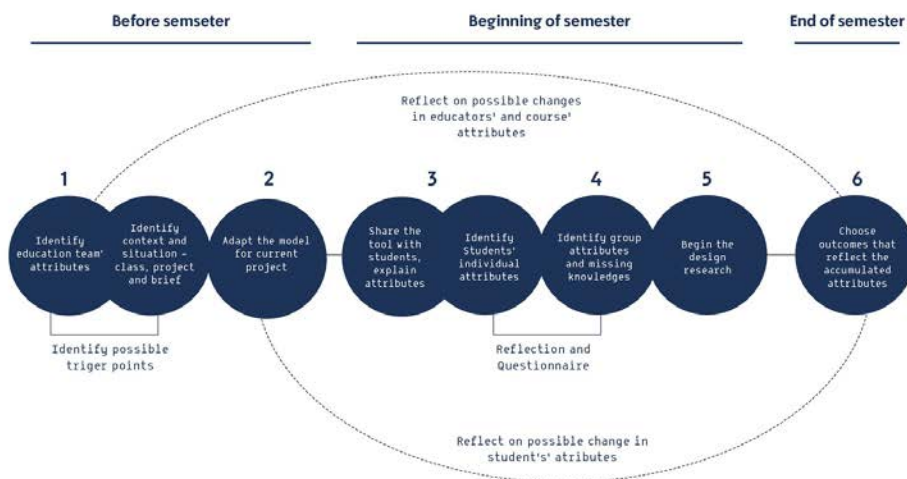


Figure 3. Process.

In the next sections we will describe our experience of using the tool and share reflections and conclusions for future research.

Methodology

We applied the tool with our students through several iterative phases. The initial iteration took place during a Health Design Lab course in May 2023 at Shenkar, Israel. Subsequent iterations were conducted within four design courses between December 2023 and January 2024. These iterations spanned different locations, including Israel and Germany, and covered various design programs. At the bachelor's degree level (BDes), the model was applied with students from the Department of Visual Communication at Shenkar and by students from the Inclusive Design program at HAC Jerusalem. At the master's level (M.Des, MA), it was applied with students from the MA Transformation Design program at TH Augsburg, and with the M.Des Interdisciplinary Design program at Shenkar, Ramat-Gan. These iterations reflect a diverse range of educational settings and focus areas within design studies.

Table 1. Summary of case studies

#	1	2	3	4	5
Date	May 2023	January 2024	January 2024	December 2023/ January 2024	January 2024
Location	Israel	Israel	Israel	Germany	Israel
Program	B.Des, Cross-disciplinary studies Shenkar	B.Des, Department of VC Shenkar	M.Des, Shenkar	MA Transformation Design, TH Augsburg	B.Des, Inclusive Design, HAC Jerusalem
Number of students	12	19	20	15	30

In the current application of the tool, five facets were selected by educators at the beginning of the course. This selection was made through discussions among the educators, drawing on our collective experiences as both educators and practitioners. We identified facets that could be universally applied across different courses (see Table 2). Certain attributes were modified to align with the unique context of each course. For example, we chose a facet for “core values” that we would like to incorporate as part of social design education in general. These core values were consistent across all courses, with students selecting those most pertinent to them. Other facets, such as “religion,” varied between courses to reflect the differing religious contexts of countries like Germany and Israel.

Table 2. Comparison between facets and attributes for the different locations

Attributes		A	B	C	D	E	F
1	Gender, Germany	Female	Male	Non-binary	Fluid		
	Gender, Israel	“	“	“	“		
2	Cultural Group, Germany	Atheist	Christian	Muslim	Jewish	Undefined	
	Cultural Group, Israel	Jewish	Muslim	Christian	Undefined		
3	Main Discipline, Germany	Visual	Product	Digital	Fashion	Other	Multi
	Main Discipline, Israel	Print	Motion	Digital	Illustration	Other	Other
4	Expectations, Germany	Signs &	3D Objects	Services	Systems		
	Expectations, Israel	“	“	“	“		
5	Core Values, Germany	Commercial	Participator	Glocal	Ecological	Speculative	
	Core Values, Israel	“	“	“	“	“	
6	Resilience, Germany	Physical	Cognitive	Emotional	Meaning		
	Resilience, Israel	“	“	“	“		

In all courses, we implemented the tool at the beginning of the semester, before students started their projects or formed groups. This approach aimed to assist students in finding team members with shared interests and backgrounds, or alternatively, to intentionally introduce tensions and diverse viewpoints into their projects. The initial phase involved explanation, followed by conducting the mapping activity. In three courses the mapping activity was done during class (B.Des, Inclusive Design, HAC, B.Des, Cross-disciplinary studies Shenkar and Mdes Shenkar) while in the other two courses, it was completed independently after class (B.Des, The department of Visual Communication Shenkar and MA Transformation Design, TH Augsburg). The mapping activity concluded with an oral discussion and a questionnaire designed to evaluate the visual model's overall concept and its different modules. The questionnaire (see appendix A) was made of 15 questions, ranging from background data (age, academic program etc.) to reflections on the model (which representation was easiest to understand, for example). In the MA Transformation Design course at TH Augsburg, the educator facilitated an extended reflection session to gather students' impressions and experiences. In Fig. 4 we see an example for use of the model.

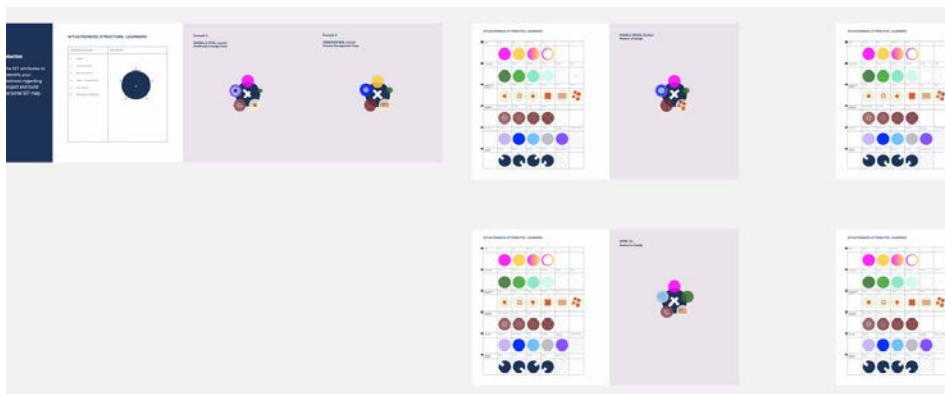


Figure 4. Part of the Miro board from the M.Des Interdisciplinary Design program at Shenkar..

Outcomes

Among the 96 students participating in the research, we collected 92 visual models and 35 questionnaires. The visual models underwent comparative visual analysis, while the questionnaires were evaluated through a classic qualitative thematic interpretation. The students' overall response to the activity was positive. Many students noted that the tool encouraged reflection on their expectations and goals before starting another semester. For others, the activity facilitated reflection on their own situatedness before engaging in a collaborative design process. The responses were categorized into five main themes:

1. Usability

Assessing the usability of the model was one of our main concerns. We questioned whether the terminology was clear, if the shapes were intuitive, among other usability aspects. Unsurprisingly, gender identification was the easiest to understand (85.7%), albeit some commented on our colour coding. Feedback from the comparative visual analysis led us to direct modifications, including the addition of small post-its on each Miro board to clarify different parts of the model.

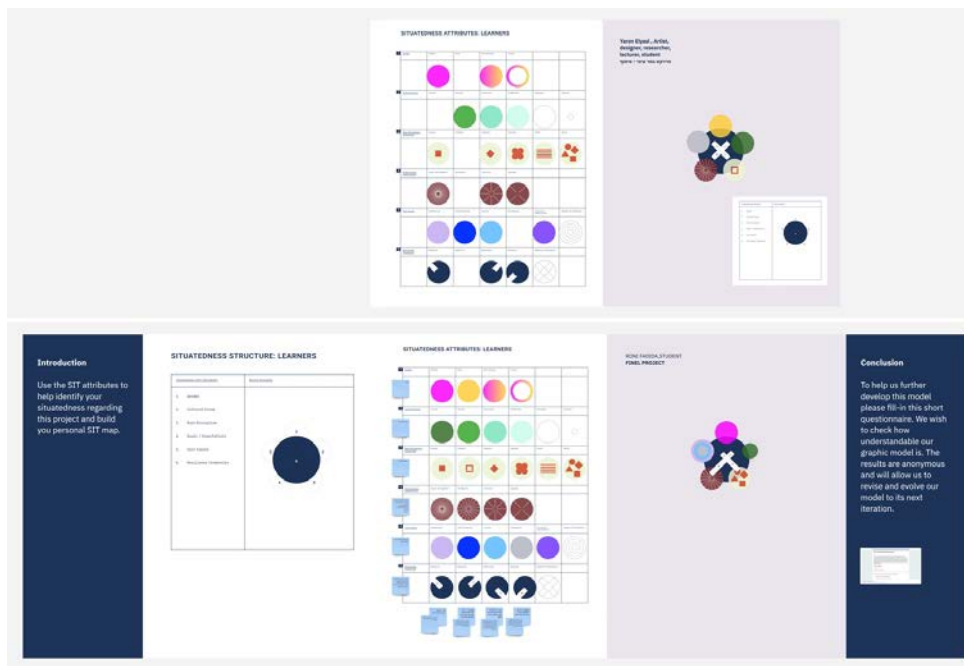


Figure 5. Top: Original Miro board design with a student suggestion to include the legend closer to the area of interaction. Bottom: The design iterations integrating a legend, explanation in Hebrew (the blue post-its), and a direct link to the questionnaire.

Another interesting point was when we asked, “If you would have to add another attribute, what would it be? what would be its possible answers?”, two interesting comments were:

From the top of my head, and as i understand this tool is supposed to be used in the learning ecosystem, mahbe something about leadership role. Or group role, like if i am in a group what kind of role do i choose, leadership always, leader if needed, listener, collaborator. I am just making up words here but maybe it would be useful for a teacher to know how to approach and take advantage of each student abilities in the group management environment.

I would add core values as a person, and not only creator. I think it would express the 'resilience tendencies' in more than one tendency - but more of a mix of personal values. My mix would probably be - communication, transparency, dedication, sustainability, playfulness and some

Figure 6. Answers from the questionnaire.

These comments reveal that competencies related to group communication should be further incorporated into the tool and, more broadly, into Social Design education.

2. Agency and creativity through improvisation

We aimed to assess the added value of a newly developed visual tool designed for data generation activities. Notably, while approximately 90 students engaged with the visual diagram, only 35 completed the accompanying questionnaire. This disparity suggests two possible reasons: firstly, designers are more accustomed to thinking and reflecting visually, and secondly, visual tools may facilitate a deeper connection when addressing subjective and emotional issues such as identity formation and socio-cultural backgrounds.

Another interesting insight is that many of the students thought of the visual model as a flexible suggestion. We observed numerous variations on our proposed structure, including multiple filled options, various options depicted together, going “beyond the lines”, etc. Fig. 7 and 8 illustrate these variations. Unlike more conventional digital questionnaires, our tool encourages improvisation, agency, and playfulness, fostering a creative approach to generating and interpreting personal data. This approach aligns closely with the designerly way of thinking and working. Furthermore, this type of mapping activity effectively engages both cognitive and visual skills simultaneously.



Figure 7. "Expected" use.



Figure 8. "Accidental" interpretations.

3. Power hierarchies in the classroom

Although there was a designated place for students to fill-in their personal details (name, role, and class) some students preferred to do the activity anonymously - highlighting that they can not ignore the power relations within the context of a class. Some didn't even want to do the activity on the shared platform and asked to copy the activity to their own board. Others mentioned that answering this type of questions can be stressful, but that working with the visual model made it more pleasant, commenting on the aesthetics of the metaphor of a flower as a symbol for growth. We can learn that personal attributes are not always easily shared in a classroom setting or through these types of tools, and maybe students still prefer not to share them with their educators or even with their peers.

4. Identification of personal biases and missing perspectives

Several students noted that the individual mapping activity enhanced their understanding of the perspectives they could contribute to projects, as well as those that might be absent. This realization is particularly crucial in social design education and when engaging with communities. Identifying missing perspectives is essential, as it prompts the inclusion of these perspectives in the design research, enriching the process and outcomes.

5. Empowering adaptation

The tool serves initially to analyze the current state of a student's profile, offering a snapshot of their starting point in the semester. However, its true value lies in its adaptability. As the semester progresses, students are encouraged to continuously reflect on and adapt their profiles to meet their evolving needs and circumstances. This ongoing process of reflection and adaptation allows them to respond proactively to new challenges and opportunities. Importantly, it empowers students with the agency to initiate new projects. Through this iterative process, the tool not only tracks changes but also facilitates growth and innovation, reflecting the dynamic nature of design education.

This research provides a foundational understanding of how a reflective visual dialogue tool applies within social design education and underscores its potential for future development. The introduced themes illustrate that it has effectively engaged students with complex issues by leveraging emotion and subjectivity, thereby fostering more diverse conversations in the design process. The mapping activity particularly catalyzed discussions centered around personal attributes, filling a notable gap in social design education. Looking ahead, there are several promising opportunities to expand its use. One such opportunity involves transforming the model into a participatory activity where students select the facets at the beginning of the course, thereby tailoring the learning experience to their needs. Additionally, the tool could serve for curriculum development, particularly by collecting data about missing competencies needed in

service design education. Finally, analyzing the outcomes of projects could provide insights into the accumulated perspectives of all design partners within the project team, offering a more holistic view of the collaborative process.

Conclusions: Towards Reflective Dialogue in Design Education and Practice

While the visual tool depicted in this paper offers many insights, its use and potential are still in their infancy, waiting for further research. However, we wish to highlight several key insights stemming from our current research stage. Our contribution to integrating empathy in social design education can be viewed in three key areas: First, through this visual aid we can increase our ways of knowing - ourselves and others, adding to the understanding of intrinsic as well as extrinsic situated knowledges. While important in all venues of design, when practicing or teaching social design, the power hierarchies must be challenged, and a clear map of situatedness will greatly help. Second, our model can broaden the scope of understanding and overcoming hierarchies through critical dialogues on an equal eye level and without exclusion of perspectives. This is true both in the classroom, through revised relationships of educator-learner and learner-learner dialogues. This is also true when reframing the relationship between academic researchers and local communities' stakeholders, crucial to the practice of social design. Third, our model can help to better understand what perspectives might be missing, which voices might not be heard in the classroom (culture, gender, professional skills etc.) and augment the voice of those who might not get full attention.

Furthermore, with the growing integration of general artificial intelligence in design learning and practice, it becomes crucial for designers to acknowledge the importance of their own humanity and that of others. Recognizing people's contributions is essential for the well-being of individuals and society, as well as for maintaining the health and relevance of institutions (Cardona et al., 2023). As designers work not only in teams but with various stakeholders, this ability is even more important in the coming years.

As we have seen, the market-oriented origins of empathic design triggered a much-needed change in design practice, yet its origins continued the primeval sin of design - aiding the production and marketing of designed products. Furthermore, in most venues of social design (PD, inclusive and universal design, design for disability etc.) empathy is already embedded in our mindset from the get-go. With this critique in mind, we follow a somewhat similar oath as that of the Finish research outlined by Mattelmäki et al (2013: 68). The authors describe four key beliefs: first, people give meaning to things and act accordingly; second, design research should focus on real life; third, "research methods should come from design and visual and tactile, inspiration-enhancing, deliberately cheap, playful" [...]; and lastly, design research should be based on using design-specific means, such as visualisations and more. While we agree with this notion, we find it necessary to add a few crucial notions. First, in the decade that passed since the publication of this research initiative we find ourselves in an ever-growing world of

wicked problems, not only in quantity but in complexity. For designers to keep their relevance, empathy and indeed social involvement is not an option, but a necessity. Second, while many researchers focus on practice, any change in our discipline must start in the education of future generations of designers. Third, a part of the wicked problems we face is built on depicting dialogues, as well as humanistic and pluralistic agendas as weak and irrelevant. From a value-oriented point of view, changing these notions in the classroom through clearly defined values, as well as new visual tools, as the one depicted in this article.

Following these principles, we believe our visual tool is a step forward in a much-needed new direction: Following the principles of the UN, as well as various pedagogic principles, primary of which are SEL and UDL. We believe visual dialogues can lead to various much needed skills and competencies for the present, as well as for future challenges. By integrating our tool with the Participatory Design (PD) paradigm, students' ability to act can be further strengthened through adapting it to their needs, which can be further reinforced in the future development of the tool. Critically reflecting on which perspectives are missing in the dialogue, also helps the students to look beyond their university and appreciate the external communities with their different perspectives even more. Reflective visual dialogue is a great way to increase our ways of participatory knowing. Through this model we can conduct reverse teaching and broaden the scope of the teacher-student dialogue which can in turn enhance more agency on the students' side. Furthermore, visual dialogue, aside from accentuating and aiding empathy, helps the students' access to learning (UN Goal 4), especially when working with 1st generation students to HEIs. Moreover, using situatedness as a base for collaboration adds to our ability as educators to increase and enhance inclusivity in the classroom as well as in the design studio. We can propagate our need to always learn and evolve; emphasize the need for dialogue between students and between professionals and communities (UN goal 11). This is especially important when practicing creatively in a visual-material environment. Through using the tool, students are enabled to identify and integrate missing perspectives crucial to the challenges to be tackled (UN goal 10). Finally, empathy and situated knowledge will enhance the students' involvement in the communal work, as well as heighten their agency towards their studies and practice as well.

In sum, we believe reflective visual dialogues in social design need become an inherent central part of our toolbox as educators and practitioners, and an innovative way to face the complex and challenging future we want to transform in a just and open environment for all species (UN goal 10).

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Appendix A:

SIT model questionnaire

Hi,

We are two teachers/researchers in Shenkar conducting an applied research focusing on situatedness in social design practice and education. We will present you two parts of our research we have developed - a graphic model which you will fill out through a designated Miro board, and two questionnaires - one at the beginning of the semester and another one at its end. In this first questionnaire we wish to check how understandable our graphic model is. The results are anonymous and will allow us to revise and evolve our model to its next iteration.

Thank you in advance!

Michal and Jonathan

* Indicates required question

1. What is the title of the course you are currently enlisted * Mark only one oval.

- PostProduct Design - (BDes) SHENKAR
- MA Transformation Design - TH Augsburg
- Final project YEAR A (MDes) - SHENKAR
- Final project YEAR B (MDes) - SHENKAR
- Final project Year D (BDes) - HAC

2. How old are you? Mark only one oval.

- 20-25
- 25-30
- 30-35
- 35-40
- 40-45
- 45-50
- 50+

3. Attributes: did you find the attributes easy to understand? * Mark only one oval.

- yes
- no

4. If you answered "no", would you change, add or delete any of these attributes?

5. Among the 6 attributes, which one was the easiest to fill? Mark only one oval.

- gender
- cultural group
- main discipline
- professional expectations

- core values
- resilience tendencies

6. Why?

7. If you would have to add another attribute, what would it be? what would be its possible answers?

8. Was the graphic model easy to use?

Mark only one oval, 1 = very easy / 5 = very difficult

- 1
- 2
- 3
- 4
- 5

9. If it was difficult, what would make it easier?

10. Are circles the best suited shapes for this model? Mark only one oval.

- yes
- no

11. If you answered "no", which other shape would you choose?

12. Did a question present a "clash" between the colour and the attribute? Which one?

13. Does any colour in the model holds cultural values for you? why?

14. Was the weight distribution (small/big) in some of the options understandable?

Mark only one oval, 1 = very understandable / 5 = not understandable at all

- 1
- 2
- 3
- 4
- 5

15. Any thoughts for the next iteration?

Redefining household activities: a metaphorical approach to energy for shaping sustainable futures

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ABSTRACT

People's increased demand to use more land, water, and energy resources with the ways of using them threaten energy resources and increase climate change, but the developments that aim to solve energy and climate crises have so far been technology oriented. There is need to shift away from tech-focused future visions and include more human aspects into planned developments. Therefore, this study explored the ways of enabling people to think outside of the dominant future narratives through two main activities an interactive conference poster and a co-creative workshop. Both activities focused on people's future imaginaries and understanding its interplay with the energy-related household activities, appliances, and the need of sustainable future. The findings show that the use of metaphors can stimulate alternative future imaginaries and enable people to perceive energy-related household activities differently, hence change their consideration while performing such activities. Thus, creating the bridges between humans, their imaginaries on future's household environment and their tools that are used to perform everyday household energy-related activities can help to mitigate energy-related crises and attain sustainable future objective rather than implementing new technological developments to solve energy-related issues.

Keywords: Energy demand, speculative design, metaphors, future imaginaries, co-creation

Introduction

Background

This paper investigates the interplay between residential energy consumption, human aspects, alternative futures, and technological development by exploring how the process of designing household spaces can be a leading tool towards sustainable future. Considering the need for global energy efficiency (Sorrell, 2015), this research endeavor embraces a methodological approach that incorporates speculative design (Dunne and Raby, 2013) within the context of smart and energy-efficient homes. It reflects on how imaginative futures and sustainability principles can inform and transform the process of designing homes, and what impact this might have in relation to reduced environmental impact and enhanced quality of life.

Thus, it starts with delineating current state of energy demand and how it relates to human activities within residential environments which are increasingly surrounded by

technology. Then, it continues to frame how people predominantly deal with the future, how they envision and describe it. After providing a background information about related concept, this paper explores how individuals conceptualize the concept of future's household spaces. The study unfolds through two principal endeavors: the exhibition of an interactive conference poster which designed to engage participants in discussion about future's household appliances, and a co-creative workshop that empowers participants to collectively envision and design the future's living spaces by focusing particularly on the energy challenges while maintaining human comfort. In the light of these two endeavors, the paper aims to contribute to a broader discourse on the necessity of integrating sustainable principles into the daily household activities through highlighting the role of speculative design as a catalyst for change towards sustainable future.

Energy demand and smart solutions

People's social practices, routinized type of behaviors as everyday doings, are interwoven with energy consumption, so every country demands a certain amount of energy to guarantee that people get what they need in their daily lives (Shove and Walker, 2014). In 2018, the global energy consumption increased almost double the average rate of growth since 2010 and continued this upward trend in 2021 (IEA, 2019, 2021). However, increasing global energy demand causes energy scarcities and heavy environmental impact such as global warming (Pérez-Lombard, Ortiz and Pout, 2008). Even from the 1970s, the need of sustainable energy transition and the ways of attaining large-scale societal transformation has been discussed (Loorbach, Frantzeskaki and Avelino, 2017), but energy and climate crisis are more pressing today than ever before. Nowadays many countries consider reducing energy demand, lowering carbon emissions and hence being sustainable as the most urgent and major targets (United Nations, 2019, 2021). Their common goal is mitigating climate change as fast, cheap, and safe as possible through promising ways such as improving energy efficiency and reducing global energy demand (Sorrell, 2015). On the other hand, people spend much more time indoors compared to previous years, and their behaviors and comfort preferences increase energy consumption in households (Klein *et al.*, 2012; Ortiz, Kurvers and Bluysen, 2017; Bavaresco *et al.*, 2021). In addition, household energy consumption is responsible for 30-38 % of the total energy consumption in different European and American countries (Zhou and Yang, 2016). When people shower, lighten their buildings, cook, or watch TV, they consume energy, but people are not always aware of how much energy is used for different things. Since those activities are part of people's daily behaviors and habits, energy consumption is considered as a by-product of those behaviors and becomes covert (Schwartz *et al.*, 2015). There are some solutions to deal with increasing energy consumption such as informative campaigns to raise awareness or economic incentives or tech-based solutions.

At this point, smart energy systems and smart home technologies have emerged to cease household energy consumption, and recent years have seen many smart technological

innovations (Marikyan, Papagiannidis and Alamanos, 2019; Sovacool and Furszyfer Del Rio, 2020). Smart home technologies (SHTs) refer to digitally enhanced and interconnected systems that observe residents' home behaviors to respond to their comfort and security needs and adjust these systems' responses by forecasting (Aldrich, 2003; Harper, 2011). In addition, SHTs are considered as a core element to discuss energy efficiency and support Europe's strategic net-zero energy technologies (Sovacool and Furszyfer Del Rio, 2020; United Nations, 2021). However, 'smarter' home environments do not always mean more sustainable or better ways of living (Hilty, 2013). Apart from its so-called smartness, energy efficient SHTs bring some risks and barriers that affect people's energy-related behaviors. For example, Sovacool and Furszyfer Del Rio (2020) highlight people's hesitations and concerns about SHTs such as data privacy, technical reliability and precision, usability and learning, energy rebounds and wasteful consumption, as well as loss of personal control and home ownership. Moreover, people seem to prioritize their comfort levels rather than energy efficient considerations since their comfort zones are part of their daily routines in their homes (Kapedani *et al.*, 2022). Thus, technical approaches and high-tech solutions alone will not be sufficient to attain either smart home environments or sustainable behaviors (Rodgers, Bartram and Woodbury, 2011; Cash, Hartlev and Durazo, 2017).

The issue of tech-oriented solutions

As Loorbach *et al.* (2017) highlight, energy transition does not only refer to a technological change or improvement but also refers to a socio-cultural change that comprises routines and beliefs. However, the scholars and industry solutions have primarily been focused on technical aspects of SHTs rather than the human aspects (Marikyan, Papagiannidis and Alamanos, 2019; Sovacool and Furszyfer Del Rio, 2020). In addition, the developments that aim to solve energy and climate crises have so far been technology- and economy oriented (Loorbach, Frantzeskaki and Avelino, 2017; Marikyan, Papagiannidis and Alamanos, 2019). Hence, the role of humans is mainly neglected or their interactions with developed technologies are not considered thoroughly, and as a consequence developed technologies usually fail or become insufficient (Rodgers, Bartram and Woodbury, 2011; Sovacool and Furszyfer Del Rio, 2020; Bremer *et al.*, 2023). Based on these different theories about tech-oriented developments, this paper draws attention to lack of human aspects in the transition to sustainable energy and the future. Therefore, if humans are considered as subjects, then technological developments can be the tool that humans utilize in everyday life to achieve their sustainable future objectives, see Fig. 1. People's future can be said to be trapped in a vicious circle where technological developments for a sustainable future are mismatched with people's future aspirations. The study presented in this paper explores if these mismatches arise from a lack of understanding about what people envision for their future's life and how they describe what they imagine. Therefore, this study focuses on what people imagine about future's household appliances and energy-related activities by understanding how design can help them to describe their future

imaginaries. Before sharing more details about the study, there is need for clarification how ‘the future’ is handled by humans in the following section.



Figure 1: The mismatches between the humans, their sustainable future goals, and the technological development that prevent reducing people's energy demand. Adapted from Selvefors' (2017) activity-system model.

Future Studies and Design

People are generally curious about what the future will bring (and how it could be known) and eager to adjust their future paths in accordance with their plans (how it could be changed) (Höjer and Mattsson, 2000). However, the main problem with the future is that it does not exist yet (Hancock and Bezold, 1994), and any kind of visualizations or descriptions of the future could be considered incomplete or ill-defined (wicked) (Lockton and Candy, 2018) since no one can say if they are true or not. Many organizations and scholars have utilized future studies by generating alternative future scenarios and disrupting dominant way of thinking and making sense of the world to address the ambiguity of the future, anticipate the possibilities, and attain the desired alternative future (Inayatullah, 2004, 2008). Although future studies can support people in creating alternative future scenarios, those scenarios can be found as “flatland of futures” due to its insufficient exploration (Schultz, Crews and Lum, 2012, pp. 129).

On the other hand, the ‘wicked’ nature of the future aligns with the field of design, as many design situations are also characterized as wicked problems due to their unclear definitions, conditions, and goals, and with their many probable solutions (Rittel and Webber, 1973). In addition, the design field and its inherently future-oriented feature guide individuals and organizations to explore, analyze, and form the future through exploring ‘what if’-questions (Binder, Brandt and Gregory, 2008). Speculative design is said to bring more diverse alternative scenarios, through the practice of imagining, asking what-if questions, and generating alternative scenarios for both the current and the future (Auger, 2013). Whereas Wangel, Broms and Runberger (2021) frame speculative design as an umbrella term for all design approaches that explore alternative past, presents and futures, Dunne and Raby (2013 p. 189) describe speculative design as “/.../ a catalyst for social dreaming”. This collective mindset indicates the participatory and co-creative approach that can enrich what-if scenarios (Farias, Bendor and Van Eekelen, 2022). Thus, the interaction between design and future studies can bring

richness and multidimensions to the flatland of futures (Angheloiu, Chaudhuri and Sheldrick, 2017), and provide new insights to both fields. Fry (2015, p. 8), for example, states that the importance of design for the future is that “the future with a future for ‘us’ can only be reached by design”. In the same way, the United Nation’s Bruntland Commission frames sustainability as a future for people, for ‘us’, where both the needs of the present and the future are considered without compromising one another (United Nations, 1987). As sustainability is also a future-oriented field like design, the relation between design and the future indicates that design can play a key role for sustainability.

In addition, Pohl and Hirsch Hadorn (2007) describe how to achieve sustainable energy transition in three steps depending on gaining system, target, and transformation knowledge. Whereas system knowledge is about understanding current systems’ issues which need to be changed, target knowledge focus on desirable and plausible alternative futures (Pohl and Hirsch Hadorn, 2007; Gaziulusoy and Ryan, 2017). In transformation knowledge, there is need for potential paths that become an exploratory tool to understand how to transform current, undesirable, and unsustainable systems to more desirable and sustainable future systems (Pohl and Hirsch Hadorn, 2007; Gaziulusoy and Ryan, 2017). As emphasized within these steps, people’s current issues - and especially their desired future imaginaries and how to make them real - are by these authors seen as crucial for attaining sustainable societal and energy transformation. Lockton and Candy (2018) describe the role of future imaginaries as helping to sensitize people to how they imagine their living system – with its own dynamics – and supporting people to reveal their expectations and aspirations. In the same way, Pohl and Hirsch Hadorn (2007) define the role of future imaginaries as a tool to gain target knowledge and a necessary step to achieve sustainable societal transformation. The crucial role of people’s future imaginaries leads this study to focus more on system and target knowledge for exploring how design can help people to envision and describe their alternative and desired futures.

Metaphors as a tool for envisioning

The stated crucial role of people’s future imaginaries raises the question of how people can describe their imaginaries around future’s smart homes. The use of metaphors can, for this reason, be helpful, as when people reflect on the future especially in relation to complex and unknown or non-existent issues such as sustainable societal transformations. Metaphors is a design method that refers to a way of thinking and talking about something in terms of something else (Lakoff and Johnson, 1980), with the idea of this promoting designers to be thinking outside of the famous box concept with ‘the box’ being a metaphor in itself. People often use metaphors in their everyday life (Lakoff and Johnson, 1980), even though they might not realize it, and thus it can be seen as an unconscious habit. As Lakoff and Johnson, (1980) highlight, people are surrounded by abstract concepts, such as time, power, and space, which they tend to treat metaphorically. Metaphors are not only about the use of one thing for describing another (Lakoff and Johnson, 1980), but also about making sense of things in a fictional way. The

use of metaphor can enable people to describe their 'wicked' future imaginaries and then transmit their conceptions to someone else. Hence, the metaphorical prospects of design can become a tool for people to express their future conceptions since metaphors are said to support a reframing of the problem and 'thinking outside the box'. Metaphors are said to, for example, bring new perspectives and solutions to the problem (Hey and Agogino, 2008). As design problems are usually described as 'wicked' - and designers are said to approach them metaphorically - this design method has been and can be used for generating and introducing novel ideas during the design process (Alves-Oliveira *et al.*, 2021). People can envision and understand the abstract everyday concepts by using concrete objects. For example, the use of words such as 'desktop' and 'windows' that has helped people transcend from familiar analogue and material items to digital working platforms (Alves-Oliveira *et al.*, 2021).

In addition, when people talk about the future, they are also describing their own or their socially shared future imaginaries (Dunne and Raby, 2013). As their future imaginaries are generally abstract, they can use metaphors to re-brand one concept they are using now to define another thing in the future. One explanation to this is that people's ideas of the future are said to be grounded on their past and present mindsets (Sanders, 2001), they simply use their present vocabulary and image inventory while speculating about the future. When people use metaphors to think and talk about a non-existent future, metaphors can affect their ways of thinking and approaching the future (Alves-Oliveira *et al.*, 2021). However, if people use conventional (Inayatullah, 2004) and fossilized metaphors (Inayatullah *et al.*, 2016), their future imaginaries will not end up any different from their present. Daily metaphors should, for this reason, be thoroughly analyzed to deepen the understanding of both the present needs and the future aspirations. In addition, rather than re-employing current conventional metaphors, disrupting existing ones and generating new, alternative metaphors can enable creating alternative futures (Inayatullah, 2004).

Methodology

The Study

This study presented in this paper sets out with the intention to explore the interplay between human needs (as subject) while performing energy-related household activities through household technological appliances (as tools) and their future imaginaries on energy-efficient living environment (as an objective). This exploration has been done through the lens of sustainability, future imaginaries, and speculative design. The main approach was encouraging the participants to co-explore and co-create, so this collaborative process enabled participants and me, the researcher, to speculate about the future. The study described here consisted of two main activities: an interactive poster and a co-creative workshop. The interactive poster aimed to gather people's current mindsets (subject) that shape their imaginaries and dominant narratives on the future's household appliances alternatives (tools). The co-creative workshop aimed to provide

understanding current and alternative narratives on energy-related household activities (tools), what people (subject) desire and anticipate from alternative scenarios and how these are related with sustainable future (objective), further described in upcoming sections. Therefore, these two main activities of the study provide an exploration of mismatches between people, technologies that are used for household activities and the need of sustainable future.

The Interactive poster

Firstly, I got the invitation to design a poster for the doctoral consortium at the NORDES (Nordic Design Research) conference, held 11-23 June 2023 in Norrköping, Sweden. A poster can be seen as a relative static object; however, the intention was to use this opportunity to gather material for the study. I therefore designed an interactive poster with the aim of gaining a first understanding of what kind of future imaginaries the conference participants (subject) had about future's household appliances (tools). The intention of this poster was to enable people to interact with it and share their thoughts on post-it notes and to the researcher himself. The poster design was for this reason influenced by a past-moment-future timeline (Sanders, 2001) and future cones (Hancock and Bezold, 1994). The poster has a timeline that starts with past, through present, to future, see Fig. 2.



Figure 2: The image shows the interactive poster that was presented in NORDES 2023 (Photos was taken by author.)

Between the past and present sections, there is a series of 'provocative' images on the evolution of domestic floor cleaning products together with two 'provocative' questions and descriptive texts. The background assumption with the provocative aspects was to trigger/nudge participants into sharing their thoughts and opinions. In addition, the timeline divides the poster into hopes (preferable) section on the top, and fears (unpreferable) section on the bottom. In addition, a future section line is multiplied to three extra lines that represent impossible, plausible, and probable futures both on top and bottom parts. Furthermore, two future imaginaries were pre-attached on the poster as examples and triggers for people to interact with the poster. The intention with the

poster design was, hence, that participants should be able to react directly on the poster and to place their post-it notes with imaginaries on their future alternatives.

In this study, the intention was not only focusing on people's desired and preferable futures (a utopia) but also get a better understanding of their fears or nightmares about the future. As Sanders, (2001) emphasizes, people's memories and experiences form their present mindset and future imaginaries which can consist of their hopes and fears. In total, about 40 people interacted with the poster and the researcher during this activity.

The co-creative workshop

The other activity in this study consists of a co-creation workshop in which participants replaced energy-related household activities with metaphors and speculated on how the dynamics of those activities might change in the future. The aim was to explore current dominant and alternative narratives around energy-related household activities, then how the relation between people (subject) and energy-related household activities (tools) can change through using metaphors to reveal their desires and anticipations by creating alternative scenarios. With this goal, master's students in industrial design engineering were invited to participate and 19 students took part. The set up consisted of them being divided into four smaller groups. As Sanders (2000, p.3) indicates "tools" are needed for participants to "express themselves visually and verbally". In the workshop the participants were provided with tools previously developed by Lockton, Singh, et al. (2019). These included a worksheet for each group and a deck of image cards and concept cards were used. In addition, I created a deck of cards that contained energy-related household activities, see Fig 3. Finally, the participants had access to a generative toolkit including two- and three-dimensional components like colorful papers, wires, Legos, and dolls.

Each group selected an energy-related household activity card that they thought is a current issue and still will be an issue in the future. Then each group's participants filled in the first three steps of the worksheets based on their chosen energy-related activity. Next step was generating new metaphors for describing selected activities, so they picked cards from the image- and concept decks of cards. After following next three steps of the material canvas, they started to think about what kind of alternative scenarios there can be if they use new metaphors for selected energy-related activities. For example, whereas the group who picked charging as an issue came up with 'sealing the leakages' as a new metaphor, another group used 'de-characterization' as a new metaphor rather than saying doing laundry. The rest of the groups generated 'mindful workout sessions' and 'dance of flavors' as new metaphors for cleaning house and cooking, respectively. After assigning new metaphors for the energy-related activities, each group co-created a scene that showed either an environment, appliances, or systems based on the new metaphors created through the generative toolkit. For example, the group who used 'de-characterization' imagined an alternative everyday life

where people can de-characterize their clothes and themselves (perhaps) through a new device which is available for public use and for individual use at home.



Figure 3: The image shows one of the participants groups' worksheet and their model regarding their new metaphor. (Photos was taken by author.)

Findings

The main method for analyzing the activities was thematic analyses, since it is an approach for probing patterns within data to determine, organize and construe them (Braun and Clarke, 2006).

The interactive poster

In the poster design activity, the materials consisting of the participants' outspoken thoughts and the post-it notes were assembled based on the relations to each other. Then, these were summarized into the three overall themes of 'non-human', 'human-centric' and 'doubtful future'. The participants' future visions advocates for more-tech and autonomy were categorized under the 'non-human' theme, since they illustrate a future devoid of human attributes. Since different themes indicate humane aspects like care, fear, and hesitancy, those expressions were gathered under the 'human-centric' theme. The last theme was 'doubtful future' because each of the participants' expressions shows some kind of uncertainty or even almost impossibility. Although the most of future imaginaries on household appliances were about high-tech, another strong and inevitable imaginary is the desires and hopes of human interaction with the household appliances and in the household activities. First indication is that simplicity will be a valued feature in the future. For example, one of the participants' expressed desires which point at the main function of a kettle by saying, "smart but it is just a kettle" (Participant A, June 2023). Also, another participant underpinned the simplicity theme by sharing their vision on "having a household which is still comfy and not too tech" (Participant B, June 2023). The findings indicate that uncontrollable and unprojected situations can cause crisis of routines. For instance, one participant mentioned how covid has changed people's housing. The mainstream can be imagining a

utopia that people will be surrounded by assistive technologies. However, considering recent Ukraine-Russia war, many people suddenly faced various problems and regarding energy aspect they lived with power-outages or cuts, hence limited technology (European Union, 2023). Thus, increased climate crises and resource scarcity seems to be nudging people into also thinking of future scenarios that have limited and unsustainable technologies. From the results of this poster design activity, a finding is that technology integration in people's daily lives is inevitable since people desire more. Finally, not only people's utopias but also dystopias should be considered in future scenarios to explore different perspectives and possibilities.

The co-creative workshop

The co-creation workshop was analyzed through the collected materials (worksheets and new metaphor cards), observations, and the author's notes during the workshop. Firstly, the use of new metaphors enables people to envision alternative ways of perceptions and interactions for energy-related household activities. For example, the use of the metaphor 'sealing the leakages' for the charging activity rearranged the approach to wasting electricity. For this reason, participants thought that people need to turn off their tablets when they are not used for sealing the electricity leakages. This understanding is an example of habit substitution by destabilizing the context (Gardner *et al.*, 2021). Secondly, the use of the metaphor of a 'mindful workout session' for cleaning the house unleashed what could be seen as the problematic interaction between human and cleaning houses, such as tech dependent cleaning, more complicated, more expensive, and new ways of cleaning through new appliances rather than a simple dustcloth and a floor mop. Participants reflected that the perception of the mainstream way of cleaning the house on social media, such as steam cleaner and robot vacuum cleaner, create a social pressure. Instead, they envisioned a 'mindful workout session' that would enable them to take care of both their homes and themselves. This result also refers to the human-centric theme of the interactive poster by emphasizing human effort with an act of care and art. Thus, one finding is that the activity of defining new metaphors seemed to enable people to understand the current issues which need to be changed (system knowledge) and then focus on desirable and plausible alternative futures (target knowledge). Another perspective is that new metaphors bring a re/valuing of the energy-related household activities. With the use of the 'de-characterization' metaphor, participants added new values on doing laundry activities, hence, they reconsidered the meaning of hygiene and its norms. Adding new values enabled them to consider reducing their laundry frequency with the desire of keeping the same characteristics of their clothes, rather than washing (de-characterizing) them.

Discussion

Shove and Walker (2014) highlight that people's daily practices demand more energy. Although humans cause energy crises by demanding more energy, they are also affected from energy-related issues. Thus, this dilemma places humans at the core of the energy

and climate crises. Since the value of doing and being part of something is in human nature, every development that just focuses on technology-driven solutions will miss the human needs and desires for the future and either fail or be insufficient. As some of the participants expressed that high-tech household appliances and solutions can assist people but cannot take the lead for a long term. Thus, some activities need human interactions due to their values, like “the art behind coffee making” as one of the attendants mentioned. Technology integration will not minimize human interaction because human cannot be in an ineffective role. The study presented in this paper shows that a change on how people call and define an energy-related activity like doing laundry or cleaning the house have the possibility to change their perceptions with such energy-related activities. By just calling the activity ‘de-characterization’ or ‘mindful workout sessions’ and without adding another tech-development, the participants reconsidered the dominant norms around hygiene and the way of washing their clothes or re-value the effort that is performed while cleaning the house. In addition, the use of ‘sealing the leakages’ metaphor redefines the activity of charging a device as a waste of resources rather than considering it as refilling the power of a device. This new way of perceiving the activity can change people’s attitudes toward more energy-efficient everyday life. An important finding from this study is that there is a mismatch between technological developments, humans’ behaviors, and desires, and their sustainable future goals which should be further addressed. The mismatch can be just a misaligned point of view of an individual to the activity itself, i.e., rather than adding another technical solution, the importance is to be understanding how people perceive the present and what they envision for the future. Furthermore, humans are not passive actors who just engage with some technological tools: they are actors who live in the present and dream of a future that they want. As Selvefors (2017) highlight, a subject (a human) utilizes a tool to attain her/his objective. In this case, if humanity aims for a sustainable future and if humanity is surrounded by technology, then the mismatches between those two things needs to be better understood and addressed.

Conclusion

This paper delves into shifting away from technology-oriented future imaginaries through two different ways of encouraging people to envision the future differently. The findings indicate various future alternatives from a scenario where the human features are at the core which values the care and desires doing things by yourself to non-human approach is prioritized where smart appliances dominate chores. In addition, this study contributes to expand the field of design and future research, particularly in the employment of metaphors which seemed to stimulate alternative imaginaries. The use of new metaphors can change how people perceive or value energy-related household activities, so this shift in the thinking about such activities can enable people to both think and act differently. The main importance of this is that the human aspect is crucial to be able to develop an energy-efficient future and the many different ways humans can be included in developing that future together. The current study can be seen as a pre-

study for other activities and studies aimed at better understanding how people think about the future and what methods and means that can be used to make them think about the future to change behaviors in the present. The limitation of the study is that it was a time- and participant limited endeavor, yet the findings indicate some promising areas that needs to be further explored in future studies.

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An Inception Fairytale – Stories on the Sustainable Future in a Technology Center

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ABSTRACT

This research addresses the crucial role of the industrial sector in achieving a sustainable future amid escalating anthropogenic pressures. The study explores a Technology Center's perspective on and understanding of the future through two visual design workshops centered around the center's visualizations. The results show that, in the Technology Center, the current understanding of the visualizations in relation to the future is shaped by the idea of the visualizations as a support for making (new) things, for example new technologies, robots, systems for human-machine interactions, physical and digital spaces for industrial development. The results also show that the stories around a sustainable future evolved around economic and social sustainability, yet the narratives around the environmental aspects are less predominant. The paper contributes valuable knowledge at the intersection of sustainability, design, and industry.

Keywords: visualization, sustainable future, visual design method, manufacturing industry.

Introduction

In the light of that fact that anthropogenic pressures on the Earth system have reached a scale where abrupt global environmental change can no longer be excluded, there is a clear challenge for every sector in society to consider its role in creating a safe space for life development (Rockström et al. 2009). The industrial sector is one of those sectors with a potential huge impact and influence in creating a sustainable future.

The phenomenon of un/making in design research involves actively considering and engaging in the process of breaking down or transforming existing structures, products, or systems. It contrasts with the conventional view of design as a process of creating and building new things. Researchers and designers have begun to explore un/making as a way to address key design issues, such as reuse, repair, and unintended socio-ecological impacts. The research contributes to developing a more holistic understanding of the design process by recognizing the importance of reevaluating and reshaping what already exists. (Sabie et al., 2022). Research within un/making addresses the unintended consequences of design decisions (Lindström & Stålh, 2020), particularly in terms of environmental impact and social aspects. The adoption of un/making practices in the

manufacturing industry aligns with sustainable and circular economy principles, promoting resource efficiency, waste reduction, and responsible product life cycle management. This can lead to both environmental benefits and potential economic advantages for manufacturers.

These socio-ecological questions are observed as a central trend in research around the future of the industry (Kamble et al., 2018). The European Commission is addressing energy consumption concerns related to climate change and supply security. The 2020 strategy sets a target of a 20% reduction in primary energy consumption and associated carbon emissions, with an emphasis on maintaining competitiveness. Manufacturing, being a significant contributor to energy and resource utilization, plays a pivotal role in meeting these goals, representing 40% of electricity consumption and contributing to 30-40% of total greenhouse gas emissions in Europe (May et al., 2016).

In light of the sustainability concerns and the aforementioned research on un/making, we found it intriguing to delve into how employees at a Technology Center in Sweden envision the future. This Technology Center, built on collaboration between manufacturing industry and academia, acts like a hub for developing future competences, technology and innovation through needs-driven cooperation. Understanding their perspectives becomes crucial as we navigate the complexities of sustainability, circular economy practices, and the implications of un/making in shaping technological advancements. Exploring a Technology Center's approach might provide insights into potential strategies, innovations, and contributions towards a more sustainable and environmentally conscious future. The Technology Center presented in the study provides an interesting place to understand more about the role of visualization for a sustainable future.

Visualization and the sustainable futures

Within the field of design, design tools and futuring methods are used for envisioning alternative futures (Neuhoff, Simeone & Holst Laursen, 2022) and additionally, visualization is increasingly considered as critical to driving sustainable change, being essential in communicating the interactions, implications and impacts of the today's complex systems (Björck, 2019).

In the industrial sector various kinds of visualizations are used to envision what can be made or exploring what the industry can produce in the future, serving as decision-making tools based on visual analysis (Redondo, et al., 2020), with the aim of bringing more sustainable practices into the manufacturing industry. A review of visualization for sustainability within this context shows that visualization is used on two levels of sustainability related information, first for the assessment of sustainability and the second for presentation of data, with the first one being more predominant (Geng et al., 2022). Recent studies focus on developing visualization methods and tools used for assessing different aspects of sustainability, often having the purpose of reducing waste, improving energy consumption, and supporting more cost and time efficient production. The visualization methods and tools, such as data visualization dashboards (Jwo, Lin &

Lee, 2021; Webb, Tokhi & Alkan, 2024), interfaces for programs run on different devices (Subramanian & Kumaraguru, 2023), or data processing tools (Tekin et.al, 2020; Ishizaka et.al, 2022), provide support in monitoring, analysis and control of the manufacturing operations and systems. Müller and Hiete (2021) present in their study a visualization tool in supporting the decision-making process through life cycle sustainability assessment (LCSA), considering the three pillars of sustainability, economic, social, and environmental. Despite the visualizations providing valuable insights on all three sustainability aspects (economic, social and environmental) at the same time, based on LCSA calculations, the underlying data bear multiple uncertainties which might affect the final decision. Furthermore, the authors stress the importance of including, besides the LCSA visualizations, additional information in the decision process, such as cooperation and strategic management goals, which in their study is defined by “a presentation of satisficing or similarly sustainable solutions” (Müller and Hiete, 2021, p.9).

Focusing on decision-making and design processes for sustainable future, the previous research on visualization in manufacturing industry reveals a gap in understanding the role of visualizations and future envisioning for sustainable futures on multiple levels, in smaller businesses and regional technological hubs. There is a need for more research to explore the dynamics of future-oriented thinking and visual representations, in relation to a wider view on sustainability, in these specific settings. Addressing this gap can provide valuable insights into the strategies and perspectives of smaller businesses and regional centers as they navigate the challenges and opportunities of envisioning their future trajectories. Thus, the focus of this paper is on how the industry itself can develop an understanding of which futures connected to sustainability they want to create, mapping the visual representations in relation to the United Nations framework of the sustainable development goals for agenda 2030 (Contributions to Agenda 2030).

Methods

The main material this paper focuses on is the conversations during two workshops at a Technology center, where 16 images were the starting point in reflective sessions. The participants were encouraged to reflect and share their thoughts regarding the different visualizations, which were gathered by one of the authors during the one year of conducting research through an ethnographic study. The aim of collecting the images was to understand visualization within the context of the Technology Center, and was informed by observations, informal conversations, spending time at the Technology Center, and public information on the Center's website.

The first workshop aimed to better understand the context, the people, the organization, their values, and work practices, while the second has been designed as a follow up, based on the findings from the first workshop, exploring the participants' view on a sustainable future. The images have been used as a starting point for their reflections. The method of introducing visuals in conversations has earlier been used widely in design ethnography (Crabtree, Rouncefield and Tolmie 2012; Murphy and Marcus, 2020; Pink et al., 2022) and visuals in design ethnography has been used in industrial companies to understand more

around a phenomenon i.e. different interpretations of innovation, where visuals came to be used as boundary negotiation artefacts in group-discussion on innovation in their daily work. (Andersson Schaeffer & Eriksson 2014; Schaeffer 2015).

The main method for collecting the 16 images used as visual elicitation material has been to use the screenshot function from the author's personal computer, since all of them have been either digitally presented or publicly accessible for the researcher. All the images collected by the author prior to the workshops were included, except 3 of them that have been eliminated due to personal integrity and unknown sources. Thus, figure 1 shows the 16 images used in both workshops, placed in order from upper left corner, consisting of: factory layouts (3 images), data visualization (1 image), process mapping (3 images), 3D factory scanning (1 image), virtual and augmented reality simulations (2 images), 3D printing machine (1 image), Center's website (1 image), 3D simulation components (2 images), Gantt chart planning (1 image), office design rendering (1 image). All these images are part of the company organizational culture, created by either the participants or their colleagues for different work task purposes, or by external parties (software companies) and used within the Technology Center daily work practices.



Figure 1. the 16th visualizations used in the workshops.

During the workshops (see figure 2), six people took part in the first one and four in the second one. Both workshops followed the same structure, a 1.5-hour activity starting with warm-up questions, then introducing the images and a template used as support for their reflections. The participants were invited to choose two of the 16 images, the first workshop focusing on what they found interesting in that moment, and the second on what they could relate to their personal sustainable future. The template is divided in two sides, one for each image, each side consisting of two questions, (1) describing the image, (2) why it has been chosen in relation to the topic of the workshop, and five keywords around this story.

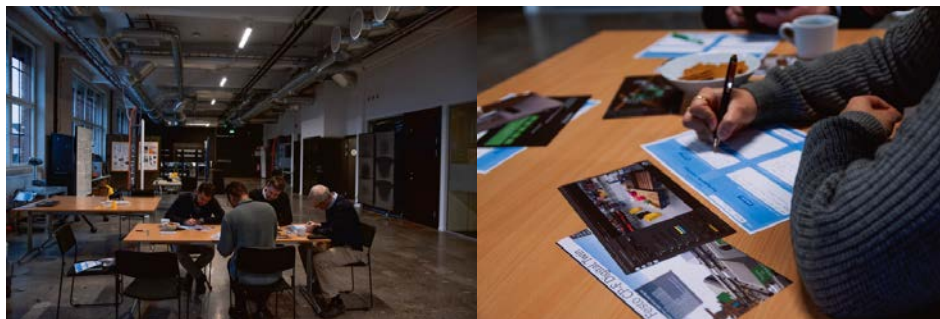


Figure 2. Photos taken during the second workshop.

This was followed by their individual reflection on the two images, filling in the template, and then sharing and discussing their insights collectively within the group. Everyone involved had the opportunity to give their input and comment on each other's images, which encouraged fruitful conversations to take place. The workshop was audio-recorded then transcribed in full, and the texts and images were gathered. The participants have different backgrounds and experience within the Technology Center, with roles and positions such as project leading within simulation and visualization, project management within data and communication, simulation engineering, operation management, project coordination, project management and doctoral student.

Analysis of the empirical data

From the empirical data collected during the first workshop, several narratives elicited by the images revolve around the idea of visualization in connection to future. The glimpses of the future were not dominating the discussion, especially in the first workshop, but the occasions when the future is mentioned is in focus of the analysis in the paper. The rest of the material is being processed for further research publications.

The second workshop concentrates on deeper understanding the Technology Center's take on sustainable future, elicited by the same set of images. The stories that came forward were placed within the United Nations framework of the sustainable development goals for agenda 2030. Figure 3 shows the sustainable development model on three dimensions, inspired by the Stockholm Resilience Center view (Contributions to Agenda 2030). To map out the future sustainability aspects arising during the workshop, we present the findings following these three main dimensions, environmental, society and economy, mentioning in the end of each story, which of the 17 sustainable development goals they might have a connection to.

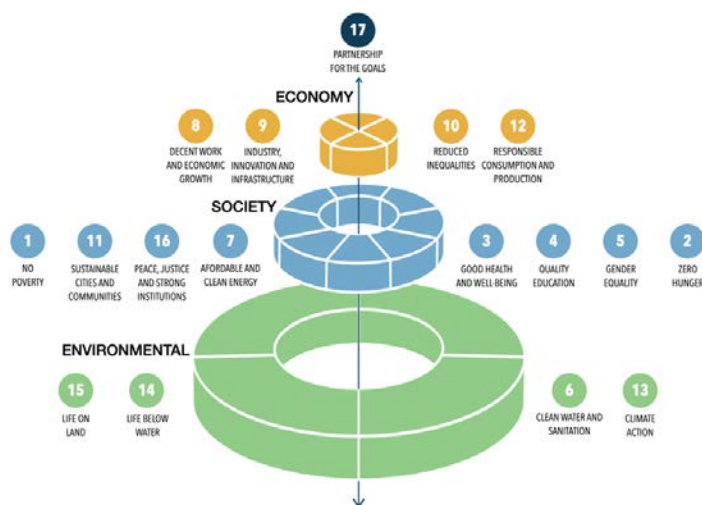


Figure 3. The 17 sustainable development goals model, inspired by the Stockholm Resilience Centre.

1. Findings

1.1 Glimpses of the future

The stories of the future that came forward in the first workshop, are shaped by the idea of the visualizations as support for making (new) things, for example new technologies, robots, systems for human-machine interactions, physical and digital spaces for industrial development (see figure 4).

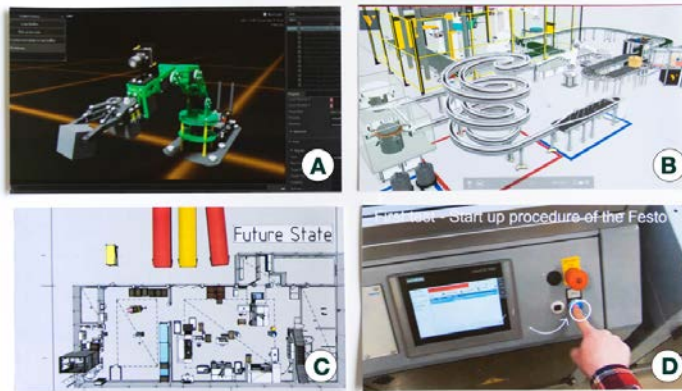


Figure 4. The four images (A, B, C, D) eliciting glimpses of future during the first workshop.

For example, Gabriel sees image (A) as a “very exciting” simulation environment, representing a future behavior, as the robot doing things in real life, becomes a “sim-to-real” (simulation to reality) journey. This journey seems to be quite “science fiction” for now, but he thinks it will soon become real. The green robot with its little grip and the small camera is like a child in the future, who learns how to conduct different tasks, based on constant feedback, like what it should or should not do. For Sebastian, another participant, seeing the robot’s transition from simulation to reality becomes boring, as the Technology Center’s journey ends after the programming process, and the robot is then integrated in the company’s work for which it has been developed. Gabriel wishes they could continue to follow the process, further expanding the robot skills.

Discussions around the future also evolved around image (B), which for David represents something futuristic he has not seen in real life. However, he recognizes that this spiral “looks like one of ours test before invest” visualizations, and it is “a picture of a well thought or analyses system” because of the different visual components of the production site. It represents a creative, futuristic system, with round shapes, that is “a bit odd compared to those pictures”, referring to the rectangular structures dominating the other images. And because of that, it looks “attractive”, with its round shapes and the spiral as the key component.

The reflections around image (C) touch briefly on the role of technology and visualization as part of the future development of the industrial processes and systems. As Noah suggests, these production plan simulations are an efficient way to test new ideas, so the

people involved can “make like actual industrial based decisions, not just [...] talking about things which are not relevant”. They provide support for making “intelligent” decisions.

Human-machine interface, reflected by image (D), brings another take on the future within the industrial landscape. Although it also includes the “normal” human-machine interface through the small screen, Gabriel reflects on creating this image “like the pinnacle of the machine-human interface”, the augmented reality technology providing another spatial dimension for interaction. Gabriel thinks this image gives “a prototype feel of what the future could be like”, a step towards industry 5.0, which is industry 4.0 with the human aspect in it. He sees industry 4.0 being “like a fairytale” and industry 5.0 being “the fairytale if we’re all there, living the fairytale”, which seems to be a long way in the future. Other participants joined the discussion, Antony referring to industry 5.0 as “a fairytale gone good, not gone bad” and Mike adding “an inception fairytale”. In the end, Gabriel mentions that making these instructions and working in this environment was “really cool” because “it was kind of a glimpse into that possible future”, being aware that “proper” augmented reality implementation is five or ten years away. However, even if working with it was “cool”, he would prefer working with the robot simulation part (image A), as it has “a lot greater impact in the future” within technological development, compared to the augmented reality part (image D), which in his view has “more of an organizational impact”.

The understanding of the visualization and what it brings to the future is influenced by the current narrative on industrial development, but can also allude to wider cultural phenomena in future-describing genres, for instance science-fiction films and the futuristic movement. Although the idea that better visualizations can support new ideas and making intelligent industrial based decisions in the future, the narrative around sustainability and technology do not come forward in the conversations, which encouraged the second workshop to take place.

4.2 Stories of the Sustainable Future

Within the overarching theme of the future to create something new, the material contains subthemes in relation to the three dimensions of the sustainable development goals. Figure 5 shows the eight images discussed during the second workshop, marked with own letters to reference them when presenting the findings below.

Economic Sustainability

Reflecting on image (E), Antony would like to see the people leaving in these kind of production scenes having stimulated tasks, working with the things they are good at and having their abilities used in “a good way in combination with this (technology)”, in order for them to have “a very good job”. Otherwise, without the people and human-centric work conditions, this technology is “just a scrap”. Gabriel’s comment on the Tesla Bot robotic humanoid, that might replace humans, makes Antony conclude that the sustainable future depends on how we will choose to integrate people into the production system,

considering the human abilities that no other component in the system have, such as analysis. Referring now to image (F), Antony suggests that there needs to be a balance



Figure 5. The eight images (E, F, G, H, I, J, K, L) eliciting the stories during the second workshop.

within the human-machine interface, considering tree degree levels: people's expertise, information and automation. As using the augmented reality glasses, the aid of technology can support ones work in showing what to do, but then "an experienced craftsman" would know what to do without this aid, because "he has the tacit knowledge", so no need for further information or automation. For Antony, adjusting this balance might lead to a successful sustainable future. (*Goal 9. Industry, Innovation and Infrastructure*)

The development of visualization is expected to affect the future sustainability aspects in industries, says Noah as he reflects on image (G), by supporting the industrial processes in making predictions on different outputs, for example waste: "if they (people in the future) run this desk production sequence, for example, how much waste it will be produced, they can do those corrections beforehand, therefore making it more sustainable". Noah thinks that the people who are responsible for the decision process are highly experienced and "have seen what went wrong", so by testing different new ideas through simulations, will offer a more accurate image of "those thousand different variables" that might occur with the course of time. (*Goal 9. Industry, Innovation and Infrastructure*)

Image (H) reminds Noah of the new possibilities aided by generative artificial intelligence to develop visualizations in the future, through multiplication and automation. This will save time of the engineers to work on multiple solutions and scenarios, supporting the sustainable development on, for example, safety issues for the operators. However, Gabriel reacts on that, as doing the work faster might bring the people to losing their job since their work can be done by other colleagues in collaboration with these technological tools. Regarding the generative tools, the participants acknowledge the high value of

craftmanship and hand-made products, and the importance of “the last building designed by human”, Antony says. (*Goal 9. Industry, Innovation and Infrastructure*)

Collaboration aspects emerge from Liam’s reflections on image (I), which symbolizes the possibility of a future in which people are responsible for shaping these relations between different actors, companies and organizations, contrary to the current focus placed on technological development: “Now we’re all working on multiple technologies, robots, simulations and stuff like that, but in the future, I want to see that people matter too.”. He brings up an example of one Swedish warehouse where the implementation of a new, highly automated system determined many employees to lose their jobs, being replaced by new people with technical skills to handle the automated system. To create the right conditions for “a good work environment”, collaboration is the key in supporting people’s learning and adapting to the new technological systems, instead of being excluded because of the lack of skills. On that note, Antony recognizes the anxiety that people feel around the rapid technological development which is “galloping in some way”, and thinks the responsibility occurs on multiple levels, from organizations leaders to communities and individuals: “There’s like a game, a dance that we must work through or dance” to find the right balance for sustainable living. (*Goal 8. Decent Work and Economic Growth*)

The time discussion arises as part of Liam’s reflection on image (J), as he sees everything that will be produced in the future “must have a sustainable, a flexible production line or process” to same time, because “time will be more expensive than buying a robot”. His reflections are supported by one of his recent experiences, participating in a project with two important companies in Sweden, where several different future scenarios for saving time were discussed. In his view, the more time people will have, the more money they will be able to earn, so time “will be more expensive than anything else in the future”. This influences Gabriel to comment on the recent years as people have become poorer “because there are such inflations”, inflations being caused by the environmental issues that gained attention in the political discussions: “the more bad environmental decisions we put into politics, it hurts us economically”. In connection to time, “we have to work harder not just to make more money, but to keep the money we earned before”, Gabriel says. (*Goal 8. Decent Work and Economic Growth*)

Everything in the future is seen as hyperlinked by Gabriel, referring to image (K). Being hyperlinked means that “everyone sees exactly what you’re doing”, having no “personal integrity”, and he compares this hyperlinked future to all the agreements one should accept today, created by “all these big companies” to aid the development of their products with “good human-machine interfaces”. Gabriel recognizes it as a good and powerful tool, but the fact that “they just know everything about you” can lead to some kind of dystopia. He reflects the role of visualization as “the only way to make things more sustainable for real is to show cause-and-effect relationship”. Yet, Gabriel thinks the visualization is only an attempt to make it work, but that might fail due to “the wrong incentives” within the system. Today people have no proper information about the objects they buy, for example, and where they might go on when discarded, compared to previous generations living on the farm, and despite creating “visualizations of all these cycles [...] it won’t work, I don’t

think". The colors on image (K) remind Gabriel of the Matrix media franchise. seeing the hacking, as counter-reaction to this hyperlinked scene, "I think people are trying to break free from it". (*Goal 12. Responsible Consumption and Production*)

Social Sustainability

To counterbalance the real word that is hyperlinked and has centralized control, Gabriel chooses image (L) as a representation of the virtual word or "the positive side of the future". For having as minimal footprint as possible, the virtual world will be the only space where people will be allowed to experience enjoyable things, no longer be available in the real life, due to sustainability regulations and environmental issues. Driving a motorcycle or experiencing the world's beauties would only be possible by putting virtual glasses on. "It's a bit bitter and sad, but that's what I see. [...] It's in a way a harsh image (because) I think we're getting more and more caught up in all the technology [...] but it's also a lot brighter (because) you can just upload a new virtual world to live in it". Yet, this technological possibility or the new virtual world becomes less sustainable because of people's lack of care about the real world. (*Goal 11. Sustainable Cities and Communities*)

A discussion on the Government's role in sustainable development arise around images (K) and (L), Gabriel reflecting on the feeling of security and control that are interlinked, as one who has control feel safe, but in order for everyone to feel safe, everyone should have control, and that is the government, or any big organization. And then, on the individual level there is no control. And if something bad happens in the society (he brings the example of shooting in schools), nobody can be held responsible and "we are like ostriches that bury their heads in the sand", because, as Antony states, the current governmental decisions are made collectively. Gabriel feels he cannot influence the big choices: "I can vote but it doesn't feel like it matters". (*Goal 16. Peace, Justice and Strong Institutions*)

Environmental Sustainability

No story related to the four sustainable goals on the environmental dimension have been discussed, still some aspects in relation to the environmental aspects could be presented here. For instance, Liam senses the fact that all the discussions around the table contain a negative feeling on the future, naming technology as the reason for it. Gabriel also thinks that none of the images used in the workshop included a positive view of the sustainable future. For him, today's take on sustainability is compared to a known quote "the road to hell is paved with good intentions". As long as people can frame something as being sustainable, even if later it might prove to not be so, things cannot be changed, corrected nor criticized. Gabriel says is difficult to talk about these issues in a good way because they have become "sacred", and as "you can't criticize certain things in today's society, [...] then you can't learn anything, and then [...] it won't be good, but it will go to hell, I think.". Yet, to bring the more sustainable and positive side, Gabriel envisions, as part of the image (L) reflections, a society in which people feel good, are free, and more connected to nature: "I think the sustainable future [...] it's less virtual and more real, so to speak."

Sustainability as a missing part of the daily work in industrial projects was also mentioned by Noah, considering sustainability as the key aspect that influenced him the most after the workshop: “we don't really talk about it. I mean, for people from production and shop floor, they're not really concerned with sustainability at all. Not seen up till now, anyone actually using that word. So yes, I mean, I haven't, that's my experience. The focus (of their projects) is completely different”. On that note, Antony comments that sustainability might be brought up in the discussion in the previous stages of these projects, as then is more taken for granted: “and you don't need to focus on it, because that's not.... that's another issue that's been dealt with earlier in the project or something like that.”.

Discussion

Technological Tensions and the Spaces Left Blank

The stories provide a sample of what types of narratives might be produced as a reflection on the sustainable future within the industrial context, through the engagement of visualization. These stories might have been influenced by the research design of this study, as well as the use of visualization in an alternative way than its regular use in manufacturing industry. The types of visualization have also an impact on the sustainability goals these stories are associated with, and which are the spaces left blank (see figure 6). The economy and society level has been predominated in the narratives, as most of the stories reflect upon a sustainable technological development in the future.

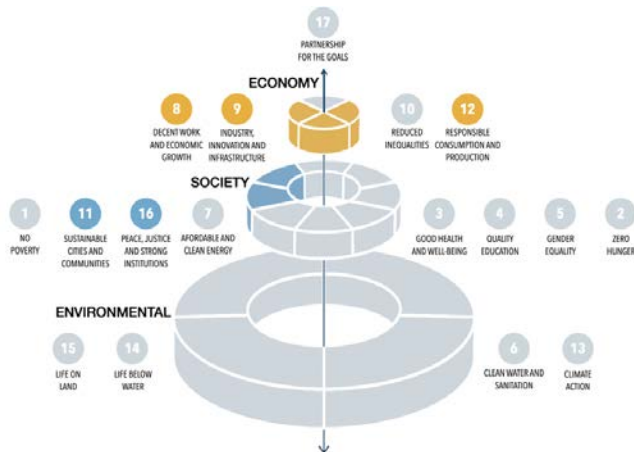


Figure 6. The sustainable development goals connected to the stories.

Several tensions are revealed, due to the uncertainties and insecurities among people as an effect of the “galloping” technological development, as Antony remarks, which is expanding under the power of the big organizations that might have own interests at state. The lack of control generates fears on the society level, mirrored through the sustainability development goals 11 and 16, as people’s everyday life is affected. They have been reflected throughout the stories presented above, such as Gabriel’s description of the future virtual reality world as an alternative for the real one, in which people will

have limited opportunities, power and control, due to the sustainability impact and future regulations. On the economy level, a more human-centered approach within the industrial sector is associated with sustainability goals 8, 9 and 12, which acknowledge the importance of people's wellbeing in both everyday life and work contexts, being a collaborative act between people, technology, and organizations, as found in Liam's and Antony stories. On the same economic level, Noah's stories on developing more sustainable practices within the manufacturing processes is also supported by the current literature on visualization in relation to sustainability, aiming for aspects such as better decision making, reducing waste or developing more energy, cost and time efficiency.

This sustainable development goals model is a visual representation of the findings in relation to a bigger frame around the sustainable future. The stories exceeded the sustainable goal expected to be recognized within the Technology Center (*Goal 9. Industry, Innovation and Infrastructure*), towards four other goals. However, the narratives around visualization bring a colonial view on envisioning the sustainable development of the future, narrowed down to the human voices. Thus, further research is needed for both expanding this view and deepen understanding the manners in which design thinking, researching, and un/making have potential in bringing up the spaces left blank, and also exploring the visual culture and its implications in relation to environmental aspects, in contexts such as the manufacturing industry, calling for attention on the environmental impact, as it stays at the base of the other sustainable goals on the society and economy level.

Visual References in Shaping the Future

In the workshops when the participants discuss an image related to augmented reality technology, the future with more and better technology the current state of industry is described "like a fairytale" and the future state of industry "the fairytale if you're all there, living the fairytale". The other participants engage in the conversation at this point and Antony adds that it is a positive development, a utopian future more than a dystopian since a fairytale gone good, not gone bad and then the story about future bend into things that we almost only see in sci-fi movies with the term "inception fairytale" added by Mike. The references from futurism to the inception fairytale of the future are pointing at stories about the future in the Technology Center that is in line with deep roots of modernism and futurism, and is a part of the history of industrialisation. The ideals of modernism and futurism and their impact on the industry's ability to reflect on and create a sustainable future is complex and touches upon various aspects of society, culture, and technology. Modernism and futurism can sometimes be characterized by a strong belief in technological progress without careful consideration of its long-term consequences. Emphasis on the new and innovative may lead to prioritizing innovation over sustainability, which can be problematic if it results in resource waste or negative environmental effects.

Unreflective ideals within modernism and futurism may emphasize short-term gains rather than long-term sustainable solutions. It can pose a challenge for the industry to

invest in and develop technologies that are both future-proof and environmentally friendly. On the other hand, modernism and futurism can inspire creativity and innovation, crucial for addressing sustainability challenges. Embracing new ideas and technologies may allow the industry to find ground-breaking solutions to reduce its environmental impact.

Un/making with Visual Methods

Albeit the workshops being a product of design, following the perspective of un/making, this study encourages taking a step back and interact with visualizations in manufacturing industry in an alternative way, rather than their regular use in optimizing and improving industrial processes and systems. The visualizations were introduced as a way of creating spaces for personal narratives to emerge, reflecting around a sustainable future, engaging in the process of breaking down and transforming existing structures, and opening the possibility for other things to be explored. Examples of un/making can be traced from the participants stories, such as Gabriel's reflection on reframing the existing societal systems, characterized by hyperlinking and interconnectivity, as they might lead to "dystopia" due to the "wrong incentives" that form their basis. The use of alternative virtual realities is another take on un/making practices, as one way of enjoying life and experiencing things that would "no longer be available due to sustainability regulations and environmental issues" as Gabriel said. However, this idea is criticized, as people might be less caring about the real world, becoming "less sustainable". Another example of un/making is Liam's reflection on the future employment, and the need for reconfiguring people's competences, as they might lose their jobs due to the lack of skills needed to handle the highly automated workplaces: "I want people to matter too, in the future".

To a certain extent, all the stories presented in the findings could be viewed as a shift towards un/making harmful relationships derived in the aftermaths of previous practices, designs, systems. And this is grounded in the method itself, which is a product of a two-year PhD journey, where participatory design has been the guiding approach in studying visualization in manufacturing industry. This approach was complemented by a resistance to adhering to the idea of optimizing and improving the existing visualizations, sensing the need of questioning the conditions of these designs in a broader way. The use of visualizations is an attempt to bring alternative views to their regular design process and application, through distance (reflecting over the aspects that these visualizations carry with them) and closeness (eliciting personal stories, meanings, and emotions).

This paper presents a first attempt of introducing the design practice of un/making within the Technology Center context through the visual method and stories around sustainable future, showing our take on engaging in the dialog opened by other design scholars (Lindstöm & Ståhl, 2020; Sabie et.al., 2022) in exploring and involving un/making anthropocentric and progressivist imaginaries, in order to create space "for a design practice that takes responsibility for its past and how it matters for what is yet to come" (Lindstöm & Ståhl, 2020, p.19).

Conclusions

This paper provides an example of how design and design thinking can be used to reflect individually and collectively on the existing structures, as well as bringing possibilities and fantasise about the sustainable future of our environment, society and economy. From this rather small study, the result shows that the stories around the future and specifically a sustainable future are related to social and economic sustainability, but the narrative around environmental sustainability is less prominent. The method might be criticized that some important aspects are omitted due to the materials used, but the visualizations are still a main part of the organizational culture, providing valuable insights. Industries may need to reconsider the historical roots of the reasoning to produce the new, their production methods and consumption patterns to create a sustainable future. For this future “to go good not bad”, it is important to consider broader views and critically thinking on the whole ecosystem, starting from incorporating more approaches rooted in the environmental level and following their way up to social and economic sustainability.

In an attempt of un/making current designs, practices and systems, the method presented in this paper, uses ethnographic approach in collecting screens shorts from the Technology Center's daily work, bringing them as elicitation artefacts to support the participants reflections, and applies the findings on the sustainable development model for analysis. By that, the method proposes a way in which studying visualization opens the possibility of reflection on the sustainability aspects within the context of manufacturing industry, with the possibility to be extended to other groups or organizations, creating a base for decision making on sustainable futures. However, more research is needed to have a fuller understanding of the future thinking around sustainability in industry and the strengths and weaknesses of the method.

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Reimagining Sustainable Innovation: ReEVOLUTION 6, a Design Thinking Model for Circular Economy

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ABSTRACT

This paper explores the integration of Design Thinking (DT) with Circular Economy (CE) principles to drive sustainable innovation. Despite growing interest in CE, obstacles to its implementation persist due to limited comprehension among stakeholders. By connecting DT's creative and collaborative approach with CE, this study aims to enhance understanding and application of CE strategies in innovation projects. We examine the potential application of DT in transdisciplinary innovation projects focused on CE through a series of trainings. A specific DT model, tailored to CE, is developed, tested, and validated in an educational context and through interviews with innovation experts. We came to the conclusion that specialists appreciated the model for its contribution to much-needed awareness and knowledge of CE. The paper concludes with insights and limitations of the proposed *ReEVOLUTION 6* model.

Keywords: Design Thinking, Circular Economy, Process Model, Education for Sustainability, Innovation

Introduction

Recent years have seen an increase in environmental awareness, and governments, professionals, and academics have been increasingly interested in the Circular Economy (CE) notion as a system and a set of strategies for sustainable development (Arruda et al., 2021; Santa Maria et al., 2022; Purvis et al., 2023). However, there are still many obstacles to the Circular Economy's implementation, including lack of knowledge and comprehension among stakeholders. Purvis et al. (2023) understand CE as an “umbrella term” with an openness for being adopted by the various actors. Even with or because of this flexibility in the definition of CE, many organisations, businesses and people are unfamiliar with the concept and its core principles, and do not completely understand the advantages it provides. Connecting Design Thinking, as a collaborative and hands-on innovation method, to Circular Economy, may help to improve the comprehension of CE principles and their application in innovation projects.

Design Thinking (DT) drives sustainable development with its life-centred problem-solving approach. It fosters creativity, iteration, and co-creation among stakeholders, aligning solutions with collective needs. Integrating CE's practices into DT involves

adapting the DT process and tools with circular economy strategies to achieve greater eco-impact, as well as drive social change.

In this paper we will explore the potential application of Design Thinking in transdisciplinary innovation projects focused on the Circular Economy through a set of trainings. We will share the development of a specific DT model, tested in an educational context and validated through expert interviews. As the Circular Economy requires a systemic and collaborative approach, DT as a holistic innovation method could provide a framework to guide such projects.

For this reason, we dedicate this study to the following main questions: Can the Design Thinking process and its tools be effectively adapted to integrate Circular Economy principles and strategies, aiming sustainable innovation? And what would a guiding Design Thinking model for Circular Economy look like?

To achieve these objectives, our paper provides an overview of the Circular Economy and its relationship with Design. Based on this theoretical basis, a DT model focused on CE is proposed, which adapts the structure of a general DT model to the specific needs and challenges of CE projects. After describing the Design, Testing, and Validation of the model, we will present our conclusions, also identifying some limitations.

Circular Economy and Design Thinking

The connection between Design and Sustainability dates back to the early 1970s, but even today more sustainable economic models such as the Circular Economy are not widely practised (Andrews, 2015). Early environmental design initiatives, including Ecodesign and Cradle-to-Cradle design, aimed to minimise environmental impacts. However, they lacked deep social dimensions and systemic complexity, leading to calls for a more comprehensive approach. In response, systemic design strategies, such as Product-Service Systems (Ceschin & Gaziulusoy, 2016) and Design for Social Innovation (Manzini, 2015), emerged to address broader sustainability challenges. These approaches emphasise social change, recognising the need for holistic solutions that integrate environmental, social, and economic considerations. In this context, Circular Economy principles intersect with design methodologies to create innovative solutions that move beyond traditional linear models towards regenerative and sustainable systems. This chapter explores the intersection of the CE concept with Design Thinking approaches to reimagine innovation for a more holistic and sustainable future.

The Concept of Circular Economy

The concept of Circular Economy is getting more and more attention in academic and scientific research. According to Alcalde-Calonge, Sáez-Martínez and Ruiz-Palomino (2022), scholarly publications on Circular Economy have surged from 12 in 2008 to 2355 in 2020, marking an exponential increase of approximately 200 times over just a little more than a decade. Despite this enormous growth in research, CE remains a

relatively new field, as noted by these authors. Specialists in large organisations also highlight a significant lack of understanding of what Circular Economy truly entails.

Discussing the various CE conceptualisations, Kirchherr, Reik and Hekkert (2017) show that Circular Economy means many different things to different people. To contribute towards the coherence of the CE concept, and as a synthesis of their critical analysis of 114 Circular Economy definitions, the authors define CE as following: “The circular economy is a regenerative economic system which necessitates a paradigm shift to replace the 'end of life' concept with reducing, alternatively reusing, recycling, and recovering materials” (Kirchherr et al., 2017).

A very enlightening work has been developed by the Ellen MacArthur Foundation, a NGO committed to creating a circular economy, which defines CE as following: “The circular economy is a system where materials never become waste and nature is regenerated”, synthesising CE into 3 principles: 1. Eliminate waste and pollution, 2. Circulate products and materials, and 3. Regenerate nature (Ellen MacArthur Foundation, s.d.). Thus, CE approaches aim to disrupt the wasteful and unsustainable practices of the linear economy by emphasising regenerativity, resource efficiency, and closed-loop systems. Instead of considering products as disposable items, circularity advocates for designing products and services with strategies such as durability, recyclability and immaterialisation in mind, amongst many others (Ellen MacArthur Foundation, 2013). One significant contribution of the Ellen MacArthur Foundation is the *Butterfly Diagram*, a visualisation of the circular economy concept based on McDonough and Braungart’s (2002) *Cradle to Cradle* Design framework. This framework emphasises designing materials and products with environmental and human health considerations in mind, assuming both a biological and a technical cycle. It consists of five main considerations: ensuring material health, promoting the reuse of materials, utilising renewable energy sources, practicing responsible water use, and upholding social fairness. The butterfly diagram refines and expands upon the C2C model, aiding companies in transitioning to a circular economy by reinforcing the idea that resources should be managed to minimise waste and maximise recoverable value. It illustrates the interconnected loops of the biological and technical cycles, demonstrating how this objective can be achieved (Ellen MacArthur Foundation, s. d.).

Design Thinking and Circular Economy

In this paper, when we mention Design Thinking, we're not just talking about 'Design' as a professional field or 'design thinking' as the cognitive process of designers. Instead, we're referring to it as a collaborative, transdisciplinary, holistic innovation method, as defended by the authors in several articles (Tschimmel, 2012, 2022; Alves dos Santos et al., 2023). This viewpoint allows for a methodological approach that goes beyond traditional design and encompasses fields such as innovation management, business models, services, and organisational changes. We understand Design Thinking as a collaborative method for innovation that provides numerous tools to improve, accelerate, and visualise creative processes in multi- and interdisciplinary teams across

organisations. Thus, Design Thinking can be seen as a promising approach for addressing societal and ecological challenges, as supported by other researchers (see Andrews, 2015; Manzini, 2015; Guldmann, Bocken & Brezet, 2019; Deniz, 2021; Santa-Maria et al., 2021, 2022).

Andrews (2015) argues that designers, who have historically promoted increased consumption in the global economy for over a century, now play a critical role in transitioning towards sustainable behaviour and developing a Circular Economy model. Although Manzini in his book *Design, When Everybody Designs* (2015) does not refer directly to the CE, he provides an important impetus to rethink the role of designers in contemporary society characterised by numerous and complex societal and sustainability problems. Manzini concludes that in today's world, Design is no longer the exclusive domain of professional designers but has become a participatory and collaborative endeavour involving everyone. He emphasises the importance of creating a culture of design that empowers individuals and communities to engage in collective problem-solving and sustainable innovation. We completely agree with his approach and call for action. Deniz (2021), in his paper "Sustainable Design Thinking and Social Innovation", emphasises the collaborative effort required to overcome barriers to Circular Economy adoption in urban settings. He underscores the importance of engaging various stakeholders such as local government, mobility, agriculture, waste management, and consumer education. In his perspective, professional designers play a fundamental role in facilitating shifts in Design Thinking across firms, societies, and communities. In a similar vein, Guldmann, Bocken and Brezet (2019) assert that DT is a multidisciplinary approach using design methods to address various innovation challenges. Additionally, they highlight DT's effectiveness in dealing with uncertainty by delaying definitive choices to maximise learning, making it suitable for managing complexity inherent in Circular Economy and Circular Business Model Innovation (CBMI). DT integrates customer needs with feasible business models, making it effective for managing innovation, especially in CBMIs requiring multiple viewpoints. The inclusion of both formally trained designers and non-designers, in multidisciplinary teams fosters creativity, vital for CBMI's involving multiple actors. According to these authors, DT has proven valuable in guiding the design of new CBMs. Santa-Maria et al. (2021) conducted a study to evaluate the effectiveness of applying Design Thinking to generate Circular Economy solutions for sustainability challenges in an online setting. Their research explored the use of an adapted DT approach in an online, time-limited, multidisciplinary workshop. The findings indicate that DT offers a promising method for developing CE-based solutions to sustainability issues. However, to optimise results, sustainability considerations must be integrated throughout the problem-solving process, with particular attention to framing the problem effectively.

Design Thinking models focused on Circular Economy

While Design Thinking has been widely recognised for its applicability in sustainability-oriented innovation processes, traditional DT models (such as the *Double Diamond*

model or the d.school/Hasso Plattner Institute 6 phase model) lack incorporation of sustainability concerns or Circular Economy principles unless deliberately integrated by the user. Initiating our research project, we embarked on developing a DT process model with a specific focus on CE. We sought research to understand how DT models might require adaptation to ensure that innovation outcomes align with positive sustainability effects. However, existing literature offered limited insights into this area. For instance, Shapira, Ketchie and Nehe (2017) introduced the *Sustainable Design Thinking* process model, which, while significant, did not incorporate CE principles. Additionally, they structured their model based on IDEO's Design Thinking for Educators framework, which we deem less suited for business and organisational contexts. In their study, Guldmann, Bocken and Brezet (2019) investigated the linkage between Design Thinking and *Circular Business Model Innovation* (CBMI). Through action research across six case companies, they developed a DT framework tailored for CBMI, identifying gaps and opportunities and providing tools for practitioners. Their findings offer valuable insights into navigating the complex CBMI process. Santa-Maria et al. (2022) developed the *Circular Sprint framework*, a DT process model aimed at integrating Circular Economy principles. Despite its structure based on the *Double Diamond* model and a condensed timeline, we remain sceptical about its suitability for guiding sustainable innovation projects within a Circular Economy context. Sessions limited to three mornings may serve well as introductory workshops to raise awareness, but they are unlikely to facilitate in-depth exploration and development of sustainable solutions for real-world problems. Given the limited and unconvincing existing DT models focusing on CE, we recognised the opportunity to develop a new process model.

Methodological Approach

Research for the design of ecosystemic ideas/solutions for a sustainable future should respond to a dual mission: make meaningful theoretical contributions and assist in solving existing and anticipated problems of practice. Frequently we face differences and even conflicts between the research approaches and values of scientific design-oriented, and organisation-oriented, research (Sein et al. 2011; Clemente et al., 2020). It is not easy to respond to practitioner concerns and the methodological rigour required from academia at the same time. Our research project clearly arises from a hybrid approach, the first author leaning more to academic principles, and the second more concerned on the practical benefits. For this reason, our methodological approach follows an interpretative *Action Design Research* (Sein et al., 2011) by iteratively combining the content of a Design Thinking model and the knowledge gained through literature about Circular Economy.

Following the design of the *ReEVOLUTION 6* model to validate the beta version, we have conducted five workshops involving a total of 106 participants. These workshops, facilitated by both authors, incorporated ethnographic observation tools such as field notes and photography, complemented by written individual reflections by the participants, which contributed to our learnings and insights. To further enrich our

critical reflections, we conducted ten interviews with sustainability experts from academia and organisations. In the following, we will encompass the design of the *ReEVOLUTION 6* model, followed by its testing and validation.

Our final objective is to answer the following research questions: Can the Design Thinking process and its tools be effectively adapted to integrate Circular Economy principles and strategies, aiming sustainable innovation? And what might a guiding Design Thinking model for Circular Economy look like? Additionally, we want to understand if a specific DT model for CE is justified.

The Design Model for Circular Economy - ReEVOLUTION 6

In our initial considerations for designing a Design model tailored for Circular Economy, we engaged in discussions regarding which existing DT model held the most promise as a foundation for integrating CE strategies. After analysing several well-known DT models, we decided to build upon our general DT model, *Evolution 6*² (Tschimmel, 2018). Our rationale is straightforward: all knowledge is influenced by social actors and environmental interactions. There exists no objective "truth", but rather subjective meanings shaped by the disciplinary backgrounds of individuals involved in an innovation process. Consequently, the assessment of each DT model's value is subjective and guided by users' experiences with creative collaborative processes. We maintain that there is no universally superior DT process model; innovation agents' choices are influenced by their disciplinary backgrounds and personal preferences. Hence, we made our personal selection.

Our approach involved analysing and adapting the *Evolution 6*² model and the associated DT tools to ensure it aligns with Circular Economy principles and practices, considering modifications, additions, or substitutions as necessary. The proposed model, now named *ReEVOLUTION 6*, emerges thus as a natural evolution of the *Evolution 6*² model.

The 6 Phases of the ReEVOLUTION model and 11 Strategy

The *ReEVOLUTION 6* (ReEV6) model represents a refined iteration of its predecessor, encompassing subtle yet impactful modifications. The name "ReEVOLUTION" not only denotes the redesign of the *Evolution 6*² model but also alludes to a nuanced reference to the 9 R's of the Circular Economy (Cramer cit. in RLi, 2015), symbolising an approach to sustainable resource management.



Figure 1: Comparison of the Evolution 6 model and its adaptation - the ReEVOLUTION 6 model for CE

Building upon the established foundation of the E.6² model, the ReEV6 model retains its fundamental structure of six phases, all undergoing a semantic refinement in their titles:

Emergence: This phase involves the identification of opportunities or challenges, setting the stage for the activities ahead.

Empathy: Focused on gaining a deeper understanding of the context (people and planet), this phase is based on empathy as an essential element in effective problem-solving.

Exploration: Formerly *Experimentation* (in E.6²), this phase centres on idea generation, with a dynamic and exploratory approach to creativity.

Elaboration: Transitioning from *Exploration*, this phase encompasses prototyping, testing, and development, embodying the practical evolution of ideas into concepts.

Exposition: This phase, now aligned with the circular concept, involves the presentation of projects, emphasising effective communication.

Execution: Formerly *Extension* (in E.6²), this phase embodies the practical implementation and continuous improvement of circular solutions. This name change reflects the sentiment expressed by many that the final phase should be more action-oriented, including the integration of measuring tools for impact assessment.

In addition to renaming two phases, we also opted to remove the associated DT tools from the model's graphic representation. This decision was made to enhance flexibility in selecting tools for each project.

Beyond the conceptual evolution, the ReEV6 model introduces a visual redesign (by graphic designer Marianna Mattos). Departing from the *Evolution 6*'s aesthetic, the ReEV6 model adopts a palette of pastel colours. Notably, dotted areas have been strategically integrated between phases, accentuating the permeability and iterative nature inherent in the creative process. This design choice aims to visually emphasise the fluid transitions and interconnectedness of the phases, underlining the significance of iteration and adaptability within the model (more about the design process of the model in <https://blog.mindshake.pt/category/research/>).

The acronym "ReEVOLUTIØN" goes beyond its basic labelling role; it encompasses a strategic insight that aligns with the broader objective of promoting CE projects, businesses, and initiatives. Eleven fundamental strategies, each corresponding to a letter in the model's name, have been crafted to guide and inform the development of sustainable practices:

Rethink Business Model advocates a fundamental reassessment, emphasising a value proposition aligned with CE principles, encouraging disruptive changes in key partnerships, customer relationships, and resource utilisation.

efficient use of resources refers to smart choices in material selection, recycling capabilities, and waste elimination contribute to an optimised material economy.

Emotional connection: Recognising the impact of emotional bonds on consumer behaviour, this strategy underscores the importance of an emotional design approach.

Virtualisation equates to the dematerialisation of products and services. This involves reducing material requirements, incorporating digital technology, and utilising online platforms to optimise resource use and enhance stakeholder connections.

Optimisation advocates extracting maximum value from various facets of operations, including energy, materials, products, space, machinery, transport, and communication.

Loop asserts that waste from one entity becomes a valuable resource for another. This strategy is integral to the principles of reuse, repair, and recycling.

Use Longer refers to the maximisation of product lifetime through easy maintenance and repair to combat planned obsolescence.

Transform by Design envisions upgradability and adaptability. Products are composed by parts that can be separated and reassembled easily, fostering future expansion and modification.

In Place: Organising the physical flow of resources and products on a local scale.

Ø Waste: refers to the producer's responsibility to design solutions that eliminate negative externalities such as pollution and waste.

Network encourages collaboration and partnerships across the supply chain as well as belonging to advocacy organisations.

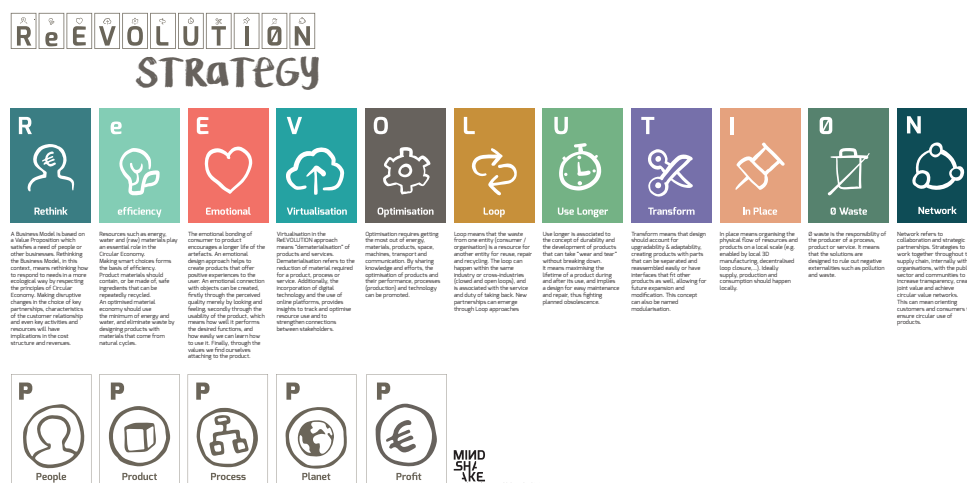


Figure 2: The 11 strategies of the ReEVOLUTION 6 model

In tandem with the *ReEVOLUTION 6* model, a dynamic card game has been developed, offering a practical and engaging avenue for participants to delve into the CE strategies. It transforms the abstract concepts of circularity into tangible actions and perspectives, fostering the understanding of CE within educational and organisational contexts. This set of cards consists of three separate categories, each contributing to a comprehensive understanding of circular approaches in a detailed manner.

Strategies Cards (11 cards): These cards elucidate the strategies encapsulated by the *ReEVOLUTION* model, each aligning with a specific letter in the model's name. From "Rethink Business Model" to "Network," these cards serve as a didactic tool, providing a tangible representation of the foundational strategies crucial for fostering circular initiatives.

Action Cards (52 cards): This expansive set outlines specific actions organisations can undertake to infuse circularity into their business practices, projects, and initiatives. Ranging from practical measures for efficient resource use to fostering emotional connections and embracing virtualisation, these cards offer a diverse array of actionable insights for organisations aspiring to navigate the circular landscape.

Poker Cards (5 cards): Drawing inspiration from the Jokers cards in a traditional deck, the Poker cards introduce a unique dimension to the game. Representing the key perspectives of People, Planet, Profit, Process, and Product, these cards prompt players to consider diverse angles in their circular decision-making, fostering a holistic and well-rounded approach.

Some Associated DT Tools and Templates

Exploring the synergy between the *ReEVOLUTION 6* (ReEV6) model and CE, our focus turns to the associated tools. These tools and specific templates (visual supports for tools), strategically placed across *Emergence*, *Empathy*, *Exploration*, *Elaboration*,

Exhibition, and *Execution* phases, amplify the ReEV6 model's adaptive approach to Circular Economy. Noteworthy tools such as *Trends Analysis*, *Challenge Mind Map*, or *Roadmap* collectively equip practitioners for navigating innovation processes, fostering the holistic development of sustainable projects. Embedded within this array of tools and their templates are those explicitly designed/adapted for CE application, such as the *Diagnosis Chart* (current contribution of an organisation, its products or services to the 11 *ReEVOLUTION* strategies), *Circularity Path* (considering the team's intention, and which strategies may be explored), *Value Chain Analysis* (analysing the current value chain and identifying gaps in circularity), *User vs Planet Journey Map* (visualisation of the user's journey and the impact on the planet when engaging with the service or product), *Stakeholder Card* (based on Personas, a characterisation of relevant human and non-human stakeholders) or *Sustainable Business Model Canvas* (transforming concepts into a business). These tools guide teams in identifying opportunities for circular practices within product value chains and developing sustainable business models (confer the complete set of templates in <https://rb.gy/hhkpl2>).

Testing and Validation of the Model

Workshops for Testing

The Context of the Pilot Testing

The initial series of workshops, held from July 13th to 22nd, 2022, focused on training teachers from diverse higher education institutions, including *Escola Superior de Artes e Design* (ESAD) in Matosinhos, *Escola Superior de Biotecnologia* at *Universidade Católica Portuguesa* (ESBUCP), *Instituto Politécnico de Bragança* (IPB), and *Instituto Politécnico de Viana do Castelo* (IPVC). The primary goal of this training was to instruct teachers in DT, enabling them to effectively integrate its principles and tools into the post-graduate courses affiliated with the *Blue Design Alliance* (BDA) project. Subsequent workshops were conducted at various intervals and locations, including another session at ESBUCP, a workshop at IPB for the post-graduate course on Health and Well-being, and sessions at IPVC. The final set of workshops occurred between October 13th and November 4th, 2023, once again at the ESBUCP. Over the course of these five workshops, we engaged with a total of 106 individuals, accumulating 152 hours of training.

The workshop participants formed a diverse cohort, including educators from HEI affiliated with the *Blue Design Alliance* consortium and postgraduate students from programmes integrated in BDA. Some participants also joined the workshops through short-term courses on Design Thinking, demonstrating a specific interest in the methodological approach rather than a focus on sustainability, blue economy, or CE topics. Most participants initially lacked a specific interest in CE, thus their reflections primarily focused on Design Thinking rather than offering insights into CE concepts.

Workshop Content and Activities

The workshops aimed at facilitating a thorough understanding and practical application of Design Thinking within the context of CE. Structured in distinct phases, each session had specific objectives, led by the process phases of the *ReEVOLUTIØN 6* model.

Session 1 introduced DT core concepts, historical evolution, and the fundamental DT mindset. It also acquainted participants with various process models, including the *ReEVOLUTIØN 6* model, so students have comparisons. Session 2 focused on the *Emergence* phase of the model, emphasising opportunity identification and introducing tools such as *Trend Analysis* and *Challenge Mind Mapping*. Session 3 delved into the *Empathy* phase, emphasising user understanding and introducing tools like *Ecosystem Mapping* and *Insight Flower* (visualising and confronting insights obtained during the *Empathy* phase). Session 4 shifted to Idea Generation, introducing tools such as *Brainwriting* and *Evaluation Matrix*. Session 5 progressed to Prototyping and Testing, emphasising concept materialisation with tools like *Rapid Prototyping* and *Desktop Walkthrough*. Session 6 transitioned to *Exposition* and Presentation, focusing on effective communication using *Storytelling* and *Sustainable Business Model Canvas*.

Each session combined theoretical discussions with practical, collaborative activities, creating a dynamic learning environment. The structured progression ensured participants gained a holistic understanding of DT for Circular Economy. The *ReEVOLUTIØN* cards were key in helping participants integrate concrete actions towards CE in their projects and were used in different moments of the DT Process.

Data Collection

During the workshop we collected informal feedback from the participants on the applied DT process and tools and the participants perspective on CE strategies and principals. Additionally, we registered our personal informal observations, capturing real-time interactions, enriching our study for a comprehensive exploration of participants' engagement with DT for CE. More formal data was collected through individual reflection papers from participants at the end of the training. The reflection papers offered first-hand accounts, providing nuanced perspectives on thoughts, experiences, and understanding of the workshop topics and applied tools.

Workshop Outcomes and Insights

From the analysis of the written individual reflections some codes were initially defined and some emerged. In the next paragraphs we'll summarise the main insights regarding some important themes:

Design Thinking method and process

Participants highlighted success in achieving specific objectives related to gaining a deep understanding of DT, experimenting with its mindset and tools, and becoming familiar with the phases of collaborative creative processes. DT is perceived as a method to transform societal challenges into solutions that add value to companies while meeting

customer expectations, applicable to various domains, from business to social sciences. The method is described as dynamic, visual, and organised, emphasising its flexibility and adaptability to diverse problems and challenges. It promotes innovation and efficiency, especially when applied systematically and collaboratively. Participants appreciated the structured approach of the DT process and acknowledged that this process is not linear and often involves revisiting previous stages. They recognised the iterative and adaptable nature of the process, which allows for continuous refinement and adjustment based on evolving needs and constraints. In their individual reflections, people highlighted the need for continuous learning and adjustment throughout the DT process. They expressed the importance of revisiting tools and stages, as well as making adjustments during project development.

ReEVOLUTION 6 Model

Among the various models considered, the ReEV6 model emerged as the preferred choice among participants, being the model used during the workshops. Its alignment with CE principles and adaptability to sustainability strategies were cited as key factors contributing to its popularity. Its relevance to current needs, particularly in revising sustainability strategies and addressing future challenges in the food and healthcare industries, was highlighted multiple times, with its potential for implementation in these fields deemed desirable and possible. Overall, the analysis suggests that the ReEV6 Design Thinking model resonated positively with workshop participants, serving not only as a learning experience but also providing practical tools for addressing challenges within the context of CE and sustainability.

Participants emphasised the importance of identifying opportunities, challenges, and problems at the beginning of the process, particularly in the EMERGENCE phase. The significance of understanding the context and the needs of stakeholders was widely acknowledged, with EMPATHY emerging as a critical phase where participants stressed the importance of understanding users' feelings, needs, and perspectives. Some participants mentioned the EXPLORATION phase, viewing it as a stage where creative thinking thrives. Regarding the ELABORATION phase, participants discussed the process of refining ideas, collaborating with the team, and translating concepts into tangible solutions, with teamwork and attention to detail highlighted. The EXPOSITION phase involved effectively communicating and presenting developed concepts or solutions, with methods such as storytelling, prototype presentations, and the business model canvas discussed. Although some mentioned the EXECUTION phase (also referred to as Implementation), the majority noted that this phase was not addressed in the workshops.

Based on the text analysis it seems that participants were particularly engaged with the first two phases of the Design Thinking process, chiefly because of the frequency of mention, the much more detailed descriptions of these phases and the emphasis given across all reflections to the importance of understanding users and the challenges they

faced in doing it. This suggests that they were actively grappling with the concepts and practices associated with empathy.

Strategies for Circular Economy

As previously mentioned, tools like the *Circularity Path* and *Diagnosis Chart* were introduced in later workshops, reflecting the iterative nature of our development process during this period. Although the ReEV Cards were provided as pedagogical material in every session, the introduction of additional tools/templates specifically mentioning *ReEVOLUTIØN* strategies made them more memorable to participants. Those who referred to these strategies demonstrated a deep understanding of the ReEV6 model and its 11 strategies (*Rethink, Efficiency, Emotional, Virtualisation, Optimisation, Loop, Use Longer, Transform, In Place, Ø Waste, and Network*). Additionally, the mention of the 52 cards representing different actions for CE indicates their practical utility in facilitating the understanding and application of strategies.

Participants noted how the *ReEVOLUTIØN* strategies enhanced teamwork by prompting reflection on the best strategies for the project being developed and fostering consideration of their specific applications, such as short-term prioritisation, long-term impact, cooperative societal value creation, and stakeholder-focused prioritisation. Moreover, there is a clear emphasis on the impact of these strategies on products, services, organisations, and society as a whole. Participants highlighted the importance of aligning strategies with core values, cooperative execution, stakeholder requirements, as well as specialisation and knowledge in strategy implementation.

Circular Economy Innovation

Participants found that working with the ReEV6 model deepened their understanding of CE principles and sustainability concepts. There is a consensus among participants about the significance of integrating CE and sustainability concepts into education. They believe it is essential for fostering environmentally conscious mindsets among students and committing to nurturing a generation capable of addressing global challenges responsibly. The DT approach, particularly using tools like the *ReEvolution Statement*, *Insight Flower*, *Circularity Path*, and the *5P* perspective, was seen as empowering for generating innovative solutions aligned with CE principles. The approach taken in the workshops led participants to conclude that DT is a valid method for its holistic problem-solving approach, considering environmental, social, and economic factors, leading to more sustainable and impactful solutions.

DT Tools integrated in the ReEV6 model

Participants generally viewed the tools used in the workshop positively, citing their effectiveness in fostering creativity, problem-solving, and collaboration. Tools like *Brainwriting*, *Mind Mapping* and *Stakeholder Maps* (renamed *Ecosystem Map* at a certain time of this process) were highlighted for their ability to generate ideas, organise thoughts, and enhance understanding of end-users and stakeholders. Other tools such as *How Might We*, *Idea Clustering*, *Pitch Presentations*, and *Sustainable Business Model*

Canvas were also recognised for their contribution to communication and collaboration within teams.

However, some challenges were noted, particularly in the application of tools like the *Evaluation Matrix*, *Insight Flower*, and *User vs. Planet Journey Map*, which required a deep understanding of concepts and context. While the *Insight Flower* was mentioned as a valuable tool for categorising insights, it may have been challenging for participants to apply effectively. Classifying insights based on categories like planet, people, profit, etc., requires a deep understanding of the context and may have been subjective or ambiguous in some cases. Likewise, although the *User vs. Planet Journey Map* was recognised as an essential tool for understanding user experiences, some participants struggled with its creation and interpretation. Mapping out the user's interactions and emotions throughout their journey can be complex, especially without sufficient data or user feedback (since this was a training setting).

Despite these challenges, certain tools stood out for their relevance to sustainability and CE innovation (based on the frequency of mention, detail of the descriptions and emphasis), including the *Circularity Path*, *ReEvolution Statement*, *5P Perspectives*, *Insight Flower* (with emphasis on Planet), and *User vs. Planet Map* (with emphasis on environmental impact).

Challenges mentioned in relation to these tools included:

Complexity: Participants found it challenging to fully grasp the concepts and principles underlying sustainability and CE innovation, especially if they lacked prior knowledge or experience in these areas.

Integration: Integrating sustainability considerations into the design process can be daunting, especially when traditional linear models are deeply ingrained. Participants struggled to balance sustainability goals with other priorities such as cost-effectiveness and efficiency.

Measuring Impact: Participants raised concerns about quantifying and measuring the environmental benefits of their solutions, especially without access to comprehensive data or tools for assessment.

Nevertheless, it is noticeable across the students' reflective texts the sense of empowerment gained from acquiring new tools, indicating participants readiness to apply DT in various professional contexts.

Through the formal and informal feedback from the workshop participants, we understood the fundamental role we played as facilitators in guiding the participants through the immersive DT workshops. The facilitator in a DT workshop not only has to establish the foundational concepts, core principles and mindsets of DT, but also provide detailed guidance on practical application of tools, ensuring hands-on proficiency. An important aspect in these tasks is empathy to individual needs, fostering an open dialogue, encouraging critical reflection, and proactively intervening to address challenges.

Limitations

The workshops spanned a year and a half, during which changes were naturally introduced to the teaching process. Moreover, they were conducted at different stages of developing and refining the *ReEVOLUTIØN 6* model, potentially leading to variations and differing emphases in the workshop content. The original set of DT tools comprised only 8 templates, but by the second workshop, we had already incorporated 12 templates into the ReEV6 model. By the last workshop, we had created 19 templates, but in this last iteration some of them were not tested. Another limitation were the discrepancies in knowledge levels and maturity among student groups, along with variations in motivations and expectations evident in workshop registrations.

Interviews for Validation

In parallel with the realisation of the last workshop and having already incorporated initial insights and introduced some minor changes to the beta version of the ReEv6 model, we conducted ten interviews with sustainability experts from academia and organisations. The aim was to gather formal feedback regarding the necessity of a specific DT model for CE and to validate the *ReEVOLUTIØN 6* model, seeking to discern what was valued and what was lacking.

Selection of Participants

The participant selection process for in-depth interviews was guided by key criteria to ensure a diverse and representative sample. Criteria included expertise in sustainability, experience in innovation projects, and proficiency in Design or Design Thinking. Participants were chosen from academia (5 interviewees) and industry/consultancy contexts (5 interviewees), all demonstrating a proven track record in CE and innovation. Diversity of perspectives was emphasised, encompassing varied professional backgrounds, ages ranging from 36 to 62, and gender diversity with 5 women and 5 men, aimed at enriching discussions and uncovering comprehensive insights.

The Interview Format

The interviews were conducted using a semi-structured format, striking a balance between predefined questions and the flexibility to delve into emergent themes. Open-ended questions encouraged detailed responses, with follow-up inquiries used to explore specific areas further. The interview guide, pre-designed and piloted, structured the conversation around broad thematic areas concerning CE innovation, DT practices and the *ReEVOLUTIØN 6* model. The predefined questions were the following:

1. Do you believe that employing a specific DT model is beneficial for Circular Economy projects? If so, why?
2. In your opinion, what intrinsic aspects of Design Thinking contribute to the success of projects within the Circular Economy realm? Please elaborate on your answer.
3. Are the six phases of the ReEV6 model suitable for managing Circular Economy projects within your organisation?

4. Can you identify any specific tools that you currently use and believe should be included in a Design Thinking toolbox tailored for the Circular Economy?
5. Upon reviewing the provided templates, do you find them useful for analysing and managing Circular Economy projects? If so, which tools do you find most valuable and why?

Each session began with an introduction to establish rapport and create a comfortable environment. Participants were briefed on the study's objectives and their role, ensuring confidentiality and obtaining informed consent before proceeding. Exactly 50% of the 10 interviews were conducted in person, facilitating interaction with materials like decks of cards and tool templates, while the rest were held via Zoom with support from the collaborative platform MIRO. Interviews typically lasted between one and two hours, offering comprehensive insights into participants' perspectives and experiences. All interviews were conducted by both authors of this paper, with one author asking the questions and the other author recording the responses, either by hand or on the Miro Board.

Data Analysis

The data analysis process was conducted by *Qualitative Thematic Analysis* (QTA) with the support of the *Delve Tool* platform, in order to manage more easily the big volume of information related to the last three questions.

Findings and Insights

In the process of analysing all recorded data (notes, sketches, photographs), we gathered all information on the *Miro board* to gain a better overview. Upon analysing the responses to each specific question, we created clusters for comparison. Our findings were as follows:

Nine of the interviewed specialists believed that the use of a **specific DT model** could be beneficial for CE projects and for raising awareness in teaching and training courses. One interviewee emphasised explaining CE in a practical, hands-on format. Initially, one interviewee rejected this question, arguing that "it should be the Circular Economy that has to integrate Design Thinking into its ways of doing things." However, after analysing all presented material, namely the specific DT tools designed for CE, she revised her opinion by agreeing that the application of a specific DT for CE model could be very beneficial in raising awareness of the importance of CE in innovation projects.

Regarding the contribution of **intrinsic aspects of DT** to the success of projects within the Circular Economy realm, nearly all interviewees highlighted the collaborative and participative nature of DT, allowing stakeholders from various fields and disciplines to engage. Additionally, two interviewees emphasised the visual and creative aspects of DT, along with its holistic approach.

Upon assessing the feedback provided by the 10 specialists regarding the suitability of the ReEV6 **process phases** for managing CE projects within their respective organisations, the majority expressed favourable views, recognising the significance of systematic approaches and frameworks in navigating the complexities of CE initiatives.

However, some interviewees noted challenges or constraints in implementing these phases, particularly in microenterprises due to scalability issues, and in certain industries like consulting and services. Additionally, a subset of specialists highlighted specific difficulties related to innovation within their organisations, including a focus on disruptive innovation and the necessity for hierarchical validation before committing to experimental projects.

Based on the responses provided by the 10 interviewees regarding **specific tools** they believe should be included in a DT 'toolbox' for CE, the *Qualitative Thematic Analysis* led us to the following insights: Most specialists emphasised the importance of a holistic approach, incorporating tools tailored to various stages of the DT process. Tools ranged from initial contextual understanding (such as *Context Mapping*) to prototyping and validation phases. Tools like *in-situ interviews* and *observation, co-creation* with core users, and *prototyping* with recycled materials were cited as effective methods for project-specific adaptation. There was a consensus on the importance of DT tools for problem framing and ideation, including templates for writing effective problem statements (*How Might We*), reframing problems, and empathy mapping to understand user dimensions comprehensively. However, some specialists cautioned against pushing DT tools and templates too aggressively, recognising potential resistance and the need for a learning curve.

Furthermore, in a more open dialogue, specialists offered suggestions for enhancing the model, such as integrating tools for detecting greenwashing, a more comprehensive consideration of material lifecycle, and tools specifically tailored to CE projects, including *Stakeholder Maps*, *Morphological Analysis* for eco-design, and *Material Suitability Assessments*.

Upon reviewing the provided **tools** of the ReEV6 model and their respective **templates**, the overall feedback from interviewees was very positive. While we cannot delve into detailed feedback within the scope of this paper, here are some critical comments and valuable suggestions obtained through QTA.

Regarding the *Circularity Path* tool, the analysis of the interviews reveals a mixed reception, with both positive feedback and concerns. Respondents appreciate the template's visual appeal and potential value for promoting a comprehensive approach to circularity. However, concerns were raised about potential confusion due to multiple paths within the same CE strategy, as well as limitations that may contradict design thinking principles (choosing paths may be limiting in earlier stages of the innovation process). Despite these reservations, there was significant interest in the tool's potential, with suggestions for enhancing engagement through gamification, strategic use and strong pedagogical support during workshops.

For *Value Chain Analysis*, there were positive reactions overall. Respondents mentioned that it seemed suitable for product analysis, and some even expressed that it was one of their favourite tools. Respondents appreciated the tool's relevance to the CE principles. Some respondents acknowledged the complexity of the tool and its template, describing

it as having many variables. Despite its potentially time-consuming nature, there was recognition that the results could be rich and valuable.

The feedback on the *User vs Planet Journey Map* highlighted positive perceptions of the tool's engaging nature and thought-provoking design. Suggestions were made for visual improvements of the template, clarity on the user's position, and inclusivity of the planet icon.

Interviewees perceived the *Insight Flower* as a visual summary tool and recognised its potential for integration with other components, such as the *ReEvolution Statement*. They suggested reviewing guiding statements and enhancing adaptability to different process phases and to service design contexts.

Respondents provided valuable insights into enhancing our new version of the *Sustainable Business Model Canvas* tool, focusing on clarity, strategic alignment, visual improvements, alternative approaches, resource classifications, ecosystem considerations, and exploring additional representation formats.

Regarding the *Implementation Roadmap*, the interviewed specialists expressed concerns about graphic confusion in the template and recommended simplification. Positive feedback was received on anxiety reduction, and suggestions were made for integrating the Road Map tool with the SBMC. The importance of material flexibility, iteration, and information permanence was also emphasised.

Conclusions and Limitations

The stakeholders interviewed who were most enthusiastic about *ReEVOLUTION 6* were people who work closely with small and medium-sized enterprises, as well as interdisciplinary innovation teams. Consultants and higher education professors also showed great interest in having yet another framework that could be integrated with others they know and use in their professional or teaching practice. Finally, we felt that for some of the interviewees, sharing our materials was also a moment of learning and reflection.

One clear limitation was the fact that feedback by the experts was given by looking at the templates of the DT tools, without ever having used the tools we specifically created or adapted to the context of Circular Economy. Some experts had shown excitement about the idea of a specific DT model for CE, but they were lacking a deeper knowledge about Design Thinking in practice.

Conclusions

This paper is built upon the premise that the design of models is dynamic and emerges from the context of both, their initial design, and continual redesign via practical use and critical reflection. This integrated view on research methodology requires bridging concerns from academy and organisational ID practices. The *Action Design Research* approach, i.e. Research *through* Design permitted us to switch between both roles and

perspectives. We always had both objectives in mind: the development of a DT model which orients its users on CE principles, and the creation of knowledge relevant for the academic design community and for design-driven organisations, committed to the production of sustainable products and services.

The literature review confirmed that Design Thinking is an effective method for sustainable innovation projects and offers potential for integrating CE strategies. Given the limited and unconvincing existing DT models focusing on Circular Economy, we took the opportunity to transform an existing DT model into a CE-specific one, called *ReEVOLUTION 6* model. The design process of this new DT model for CE and its validation phase demonstrated its effectiveness in educational and training settings. Participants in the five workshops expressed their satisfaction both verbally and in writing, acknowledging the significance of CE in today's society and in any innovation process. By the end of the workshops, they demonstrated increased knowledge of specific strategies and actionable steps towards CE engagement. Through the interviews, we concluded that specialists appreciated the model for its contribution to much-needed awareness and knowledge of CE. They recognised that most Portuguese SMEs lack specific methods and tools for engaging in sustainable innovation in a non-daunting and playful manner, thereby promoting collaboration. The analysis of interviews with specialists led us to conclude that the model is beneficial in the early stages of engaging with CE in innovation processes to raise awareness across various organisations and for guiding sustainable innovation projects, particularly in small and medium-sized companies. Considering the limitations of our investigation and the proposed model, it is evident that certain industries, especially those heavily reliant on product engineering and substantial prior investments, may find the model and tools lacking in grounded metrics to effectively achieve their desired outcomes.

All stakeholders involved in our study recognised the importance of a guiding method for sustainable innovation and identified with the model's phases and associated tools as effective support. Additionally, they valued the name *ReEVOLUTION 6* as an easy way to memorise the 11 CE strategies. The card game was specifically mentioned as an original support during idea generation moments. Furthermore, the game was appreciated as a didactic tool to introduce the concept of CE. One limitation we encountered was the time constraints in the training workshops, which prevented us from thoroughly exploring the use of the cards across all phases of the ReEV6 process.

In relation to the last research question, if a specific DT model for CE is justified, we conclude that it is. The application of the ReEV6 model by participants in the workshops revealed that integrating the CE strategies into the DT process raised awareness and prompted a shift in their focus toward sustainable solutions. The innovation specialists interviewed also affirmed the utility of a specific DT model for CE in organisations to facilitate the paradigm shift toward sustainable products and services. Furthermore, there may exist a perceptual challenge in overcoming initial resistance from clients and end-users regarding the integration of Design Thinking into the framework of the Circular Economy. However, within contexts where decision-makers exhibit heightened

receptivity towards innovative models for sustainability and innovation, this initial scepticism could potentially serve as a catalyst for constructive dialogue and adaptation, ultimately facilitating more robust adoption and implementation strategies.

To enhance the educational value of the ReEV6 model, we believe that a comprehensive toolkit comprising a conceptual introduction, numerous tools, their templates, and step-by-step instructions would be beneficial for effectively applying the model in CE

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Across the Parallax: Human-Centered Design as a Community Engagement Tool

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ABSTRACT

The UN's Agenda 2030 frames sustainable development as a collection of tangible goals that inspire us to act with a positive sense of purpose. But in recasting shared challenges as a menu of options, Agenda 2030 also makes one key assumption: people will agree that change *of some kind* is necessary. This highlights a parallax, growing over the last few decades, which has made identifying shared problems (let alone shared solutions) increasingly fraught. Today, internal disagreements within our societies have intensified, even though we occupy ostensibly shared points of view: we simply no longer “see” the same issues.

Design thinking becomes important at precisely this moment. During the last several years, our team has led design thinking workshops in Central Texas, located among the very communities that are skeptical of global-scale sustainability initiatives like Agenda 2030. Throughout our workshops, we have found that human-centered design provides a useful framing strategy, because it requires participants to set aside their own views and consider the world from a different, potentially unfamiliar perspective.

As well as discussing the context and outcomes of one such workshop, our humanistic paper proposes a theoretical framing for design thinking, re-conceived as a tool for building community. By emphasizing process over product, context over causation, and listening over speaking, design thinking has an important role to play in the future of Agenda 2030.

Keywords: community, process, philosophy, experiential learning

A cross-disciplinary method?

In March of 2015, the Chronicle of Higher Education captured attention with a provocative headline: “Is ‘Design Thinking’ the New Liberal Arts?” (Miller, 2015). Rather than discussing traditional areas of design—like product development, user experience design, or architecture—the article highlighted an emerging teaching revolution at Stanford’s Hasso Plattner Institute of Design, or “d.school,” where design thinking mindsets and competencies were re-framed as “something valuable for all undergraduates” (para. 5), including or perhaps especially students from liberal arts and humanities disciplines.

The d.school proposed to teach “a way of thinking that all students should be exposed to because it enhances their understanding of everything else they do” (para. 5). This broad recontextualization emerged from a belief that design thinking’s interdisciplinary approach to research and problem-solving would be enriched by the interdisciplinary insights new disciplines might contribute. But it was likewise supposed that students and faculty would benefit from clever adaptations of design thinking brought back to other areas of the curriculum.

Now, almost ten years after this article first appeared in print, it would be difficult to describe the d.school’s efforts as anything other than successful. Design thinking, in various iterations, can today be found sprouting across the American higher education landscape: from “design your life” classes (Burnett, 2017), to business incubators, and intensive one-day “design sprints.” Design thinking, it would seem, can be applied and used almost anywhere—and organizations, including the d.school and Design for America, have helped extend and expand its reach.

Indeed, as the need to address “wicked” 21st-century problems—notably, those defined by the United Nations’ Agenda 2030—become increasingly urgent, the luster of an inclusive, adaptive, and multi-disciplinary problem-solving strategy remains bright. Sustainable development challenges, whether expressed globally or locally, on a collective or individual basis, encapsulate the very issues that students of the liberal arts and humanities, together with their counterparts in more practical and technical design disciplines, are being equipped to address by through design thinking and related methodologies.

This has not, of course, prevented pointed critiques about effectiveness. In an article for MIT Technology Review, Rebecca Ackerman reported that, when design thinking methods were utilized at Google, “for all the excitement and Post-its they generated, the brainstorming sessions didn’t usually lead to built products or, really, solutions of any kind” (Ackermann, 2023). Ackermann’s observation provokes an important question: If design thinking sometimes fails to produce actionable results within the creative domains it was intended to support, *what possible value could it have elsewhere?*

At least as far as Agenda 2030 is concerned, our paper argues that design thinking remains compelling not because of its built outcomes, but rather, because it provides a structured form of community engagement: a tool that frames differences as valuable, and that facilitates personal discoveries through empathy and experiential learning. While design thinking outcomes may not be especially novel, practical, or unique—though some are—design thinking, reframed as a community engagement strategy, is important because it provides non-experts a low-stakes vehicle to discover the world beyond their own individual experience of it, and to imagine how an improved community might emerge.

To explain our views, this paper will proceed through several conceptual terrains. First, we will speculate, very briefly, how Western societies have reached this moment in time: a moment when it feels difficult to communicate with each other amongst a great tangle

of individualism. Second, we will explore the resulting impact on forward-looking change initiatives, like Agenda 2030. Third, we will theorize the nature of the space between individual persons as a form of “parallax”—a gap that need not, in fact *cannot*, be synthesized or reconciled. Finally, we will suggest that design thinking, understood as a form of community engagement, offers a potential pathway forward. To do this, we will discuss a particularly memorable problem-based workshop we led in Central Texas. The proposed solutions, though comparatively conventional, yielded numerous moments of personal discovery among the participants—suggesting that the most important outcome was not the final ideas, but in fact, the process itself.

Design thinking at the “End of History”

Arguably, one of the great challenges facing design thinking can be traced to the “End of History.” This concept was first proposed by Francis Fukuyama to describe, in the waning days of the Cold War, “the total exhaustion of viable systematic alternatives to Western liberalism” (Fukuyama, 1989, p. 3). In a theoretical sense, it aimed to question whether any remaining “‘contradictions’ in human life... cannot be resolved in the context of modern liberalism, that would be resolvable by an alternative political-economic structure” (Fukuyama, 1989, p. 8). In other words: if not Western liberalism, then what?

Contrary to what some critics imply (Stanley, T. & Lee, A., 2014), Fukuyama does highlight two potential competitors: religious fundamentalism, and nationalism fueled by “racial and ethnic consciousness” (Fukuyama, 1989, p. 14). But, absent monumental shifts, Fukuyama suggests that human experience at the “end of history” may otherwise be somewhat... *boring*. Rather than the spirit of “daring, courage, imagination, and idealism” required during the cold war, he saw the rise of “economic calculation,” and the “endless solving of technical problems, environmental concerns, and the satisfaction of sophisticated consumer demands” (Fukuyama, 1989, p. 18). The future, then, would involve minor adjustments to the status quo that would better reflect our values.

The debate over Fukuyama’s 1989 analysis has been exhaustive. Although his predictions may not have been entirely accurate, there is a sense that Western institutions have, in many respects, behaved as though they were. This is evident in a wide array of areas, from climate change policies and human rights initiatives to health and safety regulations. Recent years have seen the creation of varied bureaucratic processes, along with a long list of global initiatives, supported by both intergovernmental and non-governmental organizations. Concurrently, there has been a push to mobilize individual support through fundraising, volunteer work, and public awareness campaigns.

This observation—of the bureaucratization of everyday life—is not intended as a critique. Indeed, as scholars like Hans Rosling (2018) have argued, there is ample evidence of humanity’s progress over the last fifty years, suggesting that these new, technocratic layers have had a net positive impact on the people they are intended to serve. Nonetheless, the shift away from large, aspirational ideas toward smaller-scale

improvements has had unanticipated results. As Francesco Garutti persuasively argues, there is an even more specific kind of economy at work today. No longer simply technocratic and individualistic, we have a “new emotionalized economy [that] offers a market of possibilities in which the dream of self-reinvention has become a defining feature of what the neo-liberal condition offers the individual” (Garutti, 2019, p. 50-51).

For an attuned and conscientious consumer, this new economy encourages the selection of products not only for their utility, but also their ability to signal and perform a set of congruent values. For example, a hotel room no longer provides just a bed. In the new “happiness economy,” it becomes an entire wellness retreat (Garutti, 2019, p. 47). More significantly, cities, usually understood as juridical territories, now represent entire lifestyles and personal values. Indexes like the Monocle “Global Quality of Life Survey” transform communities and their histories into simple data points that can be tracked, ranked, marketed, and packaged for the public (Simpson, 2019, p. 219-220). Consequently, planners and governments can follow a veritable recipe book for human flourishing—cycle lanes, tree canopy coverage, affordable childcare—that can be applied as needed.

For the “right” audience—frequently, “the entrepreneurial, urban, and affluent” (Simpson, 2019, p. 219), or what has been called the “creative class” (Florida, 2004)—many aspects of our new individualistic, happiness-focused economy are, indeed, wonderful, enjoyable, and sensible: new urbanist developments, focused on walkability; climate adaptations that prioritize novel green and “blue” infrastructure (Fields, B. & Renne, J., 2021); farm-to-table restaurants that prize ecological concerns; transit infrastructure focused on moving people, not cars; etc. And yet, “indexes construct interpretations of well-being and livability” without giving much consideration to complex differences across space or time (Simpson, 2019, p. 216). While presenting themselves as universal, indexes like these are always contingent and contextual—requiring adaptation and modification to suit a particular individual, cultural, and social situation.

At root, though, this individualistic turn via the “happiness economy” relies upon an unglamorous, managerial, and technocratic core. Considered as a whole, it facilitates the creation of everyday lives that are intended to be sustainable, enjoyable, and supported by empirical research and well-honed “best practices.” Unfortunately, it also creates many potential points of conflict among people, their governments, and the long-term change initiatives they endeavor to support.

Agenda 2030: Conflicting Realities

In a sense, the United Nations’ Agenda 2030 emerges as an unwitting participant in the “End of History.” Within the Agenda, many of the most important challenges we face today—human rights, sustainable economic development, climate change, regional warfare, large-scale population migration, etc.—are presented, quite intuitively, through a series of discrete goals and targets that can be individually selected (or ignored)

according to personal values, tastes, lifestyles, and interests. Much like booking a “wellness” focused hotel room, or renting a home in a walkable urban neighborhood, Agenda 2030 provides us the opportunity to focus on ourselves by advancing the causes that matter to us most. It’s an appealing approach, because it offers a sense of empowered agency to the everyday (but especially middle-class) person: a sense that they possess the ability to make a real difference in areas that impact their happiness.

At the same time, by “consumerizing” critical global issues, we create many potential points of failure that might altogether undermine success. Meaning that, when contradictions and conflicts do emerge, the development of tractable solutions could become fraught. What do we do, when there is no broad agreement about the need to address—or even acknowledge—climate change, the widening global wealth gap, or access to fresh drinking water?

This is not a hypothetical problem. As practitioners engaged in community outreach in Central Texas, we frequently encounter points of view that would seem to minimize personal responsibility for shared problems. And yet, surprisingly, these same mindsets might be in congruence with Agenda 2030 itself. It is easy to believe that “everyone” naturally agrees with the policy proposals of Agenda 2030 because, in an abstract sense, it is difficult to imagine who might oppose building resilient infrastructure (Goal 9) or providing affordable and reliable access to energy (Goal 7). These are necessities for a flourishing life that many of us already take for granted. And yet, the menu-based strategy of Agenda 2030 sets-up many points of potential failure, where solving global challenges infringe upon deeply held personal beliefs and values.

This highlights a risk, and possibly a reality, in which some members of our community remain disconnected from the needs of their neighbors. Some people might simply resist change, or lack the time, interest, or resources needed to solve problems. Sadly, this apparent indifference can sometimes escalate into fear, paranoia, and more destructive attitudes. “The fact is, your government is run by the United Nations,” said one poster on the local San Marcos, TX page of social media site NextDoor:

Ever hear of ‘sustainable development’ or ‘SMART Growth’ or ‘resilience’ or ‘stakeholders’ or ‘environmental equity’ or ‘environmental justice’? All these words are rooted in Agenda 21... it’s like a computer virus [that] has now permeated every level of [government].

Indeed, problems are not problems, if they will not or cannot be seen. By providing a simple menu of options, Agenda 2030 leaves open the possibility that people will simply choose *nothing*. In situating sustainable development, climate change, and basic human needs like water and food as the expression of a kind of technocratic, happiness-enabling lifestyle choice, we risk consigning the larger global action agenda to a narrow ideological corner and legitimizing an “opt out” response from those who disagree. This is arguably the biggest conceptual flaw of Agenda 2030: it provides many more potential reasons to say “no” than “yes” to sustainable development goals.

With Agenda 2030, we face, in a way, the “End of the End of History:” a moment when the material and physical reality of climate change (and other pressing areas of global concern) cannot be reduced to a lifestyle; a moment when our individualist and consumerist tendencies are poised to work against themselves. How, then, do we make progress if we do not see the same problems?

Taking a Parallax View

The philosophical treatment of “parallax” is perhaps a useful construct here. It centers on the principle of triangulation, which posits that the location of a distant object can be determined by analyzing observations made from different vantage points simultaneously. Frederic Jameson (Jameson, 2006) explains that these perspectives are fundamentally irreconcilable: they cannot be simplified or nullified, as there will always exist some degree of separation between observers, regardless of their proximity. This inherent discrepancy, rather than being a drawback, emerges as a substantial benefit during efforts to establish an object’s location.

But if this gap, in the context of triangulation, addresses the establishment of some fixed reality beyond the individual, parallax concerns the nature of the space that separates the observers. Truth, here, is not determined relationally, but by the very existence of the gap itself. As Slavoj Žižek writes:

What we encounter here is the parallax function at its purest: the gap between the two versions is irreducible, it is ... the traumatic core around which they circulate; there is no way to resolve the tension, to find a ‘proper’ solution. (p. 19)

Parallax reveals a kind of originating trauma—a realization that we are always-already separate from each other and the world. But it is a necessary, even unavoidable realization: reflective not of a truth “out there,” like a fixed object at a distance, but manifest within us already. But this is not to suggest parallax is to be either feared or celebrated. Difference, even self-difference, is merely a fact to be analyzed and critiqued.

Žižek turns initially to Kant for some conceptual clarification. Through his reading, the phenomenon of parallax can be seen in Kant’s distinction between the “rational” and the “sensual” modes of perception (Žižek, 21). For Kant, these two disparate forms of experience simulate reconciliation within the realm of the “transcendental.” Žižek says:

What Kant does is to change the very terms of the debate ... [the] ‘transcendental’ points to something in this gap, a new dimension which cannot be reduced to either of the two positive terms between which the gap is gaping. (p. 21)

And yet, by formulating the transcendental in this way, Žižek believes the original incommensurability of rational and sensual remains intact. The parallax, then, is like a stain or an etching: a trace that lingers, even when the original chemicals have been cleaned. Even when we think a resolution has been reached, the parallax is still there.

Žižek finds a similar resonance in Hegel’s notion of synthesis—but with a difference. Hegel, he believes, approaches parallax not as a problem to be overcome, but rather, as

the very search for reconciliation itself. Žižek writes: “The distinction ‘as such’ already *is* the looked-for ‘reconciliation’” (Žižek, 27). By comparison, Kant’s weakness—and perhaps ours—is the desire to move toward “a transcendent domain beyond the realm of finite oppositions” (p. 27).

Through Žižek’s reading of Hegel, and to a lesser degree Kant, we can appreciate how differential perspectives across parallax are nothing more than incidental, while efforts towards reconciliation articulate the reconciliation itself. Parallax, then, is less like traditional dialectical synthesis—bringing two positions together into one—and more like solving for x . Or, as Žižek explains it: “the multiple emerges as the series of attempts to fill in the gap of the missing binary signifier” (Žižek, 38).

The difference between S1 and S2 is thus not the difference of two opposed poles within the same field but, rather, the cut inherent to the one term, its noncoincidence with itself: the original couple is not that of two signifiers, but that of the signifier and its *reduplicatio*, that is to say, the minimal difference between a signifier and the place of its inscription, between one and zero.” (p. 38)

Žižek and Jameson would seem to agree that it is impossible to close a parallax: the view that separates us from others cannot be sutured. Efforts at “reconciliation”—a term we often hear in the popular news media today, expressed as a desire to bring people together, or return to some prior state of mutual understanding, peace, and harmony (preceding the “pure difference”)—would therefore seem doomed to failure. There is no going back, because there is nothing to go back to; there is no hope at persuasion, because parallax can only at best be narrowed, but not closed. The gap in perspectives is always and already inevitable.

So, if differing views about shared problems cannot be reconciled, and the parallax cannot be closed, how can we make progress within Agenda 2030? And more importantly: how might design thinking help?

The Practical Role of Design Thinking: Building Together

It is odd, perhaps, that Agenda 2030 itself articulates no clear strategy for enrolling people who express severe skepticism or who altogether deny the need for change. Goal 4, “Quality Education,” is arguably the closest—but even then, it seems focused more on continuing and childhood education. So, considering the “opt out” problem discussed above, and the parallax behind it, we believe the path forward lies not simply with dialogue and discussion. Rather, it is important to put ordinary people actively to work: imagining, developing, and building new possibilities for a better future—no matter how happy their own lives may be in the present.

This is precisely where we believe design thinking shines. Of course, there is some irony here, because the roots of design thinking may be traced to the very same ideology that created the emotionalized economy in the first place (Franklin, 2023). Consequently, we believe one crucial shift is necessary to break design thinking away from its past. Rather

than focusing (and assessing) on outcome—as one might expect, for instance, in product development, workflow improvement, store design, or smart phone app interfaces—we believe it is important to emphasize the design thinking process itself. The goal, then, is not to coerce people into changing their mind—or, in more theoretical language, to reconcile the parallax. Much like Žižek’s notion of the “pure difference,” the goal is rather to emphasize the value of divergent perspectives themselves through direct collaboration, experimentation, and discovery.

Consequently, in the final section of this paper, we would like to discuss a workshop we hosted in Central Texas. This event was intended to bring together students from diverse backgrounds in order to address a vexing regional problem. The results, we believe, illustrate both the value of the design thinking process as an end-in-itself, and that people *can* and *will* work together to explore new futures if given the flexibility, intellectual freedom, and safety to learn from the experience of others.

Workshop Background

During the summer of 2021, we worked with a group of students, called the Stelos Scholars, at Texas State University (TXST). The Stelos Scholars is a highly competitive cohort program operated by the university’s Honors College. Students in their first and second year of study may apply to join, and program selection is based on academic achievements, leadership qualities, intellectual curiosity, and a desire to have a positive impact on their community (Stelos Scholars, n.d.). The program aims to teach principles of leadership through an experiential framework; and to that end, a key aspect of the program is their introductory summer workshop, in which students are asked to address a real-world challenge as it manifests in a local context.

The workshop itself usually unfolds in several phases across multiple days, loosely following IDEO/Stanford d.school and Design for America frameworks (Design for America, n.d.; IDEO, 2015). After being presented with a general challenge topic, teams consisting of 3-4 students are asked to identify key areas of concern and to conduct preliminary experiential research that allows them to build empathy with users—that is to say: people who live and experience the problem on a day-to-day basis. Next, students are asked to analyze the (qualitative and quantitative) data they have collected and to identify key areas of the problem that might be meaningfully and tangibly addressed. After defining a more focused project space, groups ideate potential remedies and build consensus around a single solution. They subsequently build a prototype or presentation that communicates their idea, and, through a tabling session or outreach event, groups collect initial reactions from the general public.

The 2021 workshop challenged students to study flaws in the local transportation system in San Marcos, Texas and imagine plausible remedies. This is no small task. As with many cities in Texas, cars are the primary means of transportation, and their impacts are cascading and multifaceted. For example, wide-spread car dependent infrastructure—such as roads and parking lots—demand a substantial amount of land

that could be reallocated to better uses (Spivak, 2018). More obviously, privately-owned cars encourage low-density "sprawl," placing a significant burden on environmental resources (Brody, 2013). They also encourage acts of dehumanization (Delbosc, A. et al, 2019) that kill tens of thousands of people every year in the United States (Insurance Institute for Highway Safety, 2023) and millions of people globally (Centers for Disease Control, 2023). Moreover, thanks to the principle of "induced demand" (Lee, 1999), we know that bigger isn't always better, and more isn't always more: building "just another" highway or parking lot will not solve the region's problems. And on a more personal level, cars contribute to the inequities in our society. Not everyone wants to drive, can afford to drive, or is able to drive a car.

As workshop organizers, one initial question we had to confront was the nature of the parallax—the points of view that were likely to be represented among our students and how best we could define, locate, and complicate them. In fact, the vast majority of our university's students have spent their lives in cities, suburbs, and small towns that were highly car dependent. Many have not traveled or lived elsewhere and have had a limited exposure to non-car forms of transit. Our goal was to leverage this unfamiliarity by framing the challenge in an open-ended way: "Design a better way to move around San Marcos." This left open the possibility that the solution might be, but need not be, related to cars; it also might be, but need not be, related to public, shared, or active transportation.

During the workshop

At the beginning of the workshop, students were assigned to work in small, diverse teams to develop a solution that would respond to the challenge. None of the participants arrived with sophisticated prior knowledge of transportation networks or associated policy, but all brought a unique disciplinary perspective and associated skillset—from arts and philosophy to communication design and accounting. Our challenge, as workshop planners, was therefore to imagine scenarios that would provide meaningful exposure to the problems we sought to address while allowing students tacit permission to leverage their own expertise in situations beyond their ordinary experience.

One particularly impactful experience involved a day trip to Austin, TX—a metropolitan area of approximately 2.5 million people. In an activity designed and lead by a faculty member from the Texas State Department of Political Science, students were challenged to experience as many different forms of transit as possible throughout the day. Along the way, they would earn "points" for the various modalities and destinations they reached. Unprompted, many students also had conversations with local transit riders and operators. As well as providing students with an experience that was outside their usual frame of reference, this activity gave them the opportunity to experience the world differently—not from another person's point of view (which is, according to the parallax, impossible), but empathetically, as though living a different life themselves.

The following day, the workshop was visited by a panel of experts from the Austin transportation system, CAP Metro. Guest experts discussed their work in transportation, but they also provided preliminary feedback on the students' ideas. Students demonstrated confidence in their understanding of the local transit system (or lack of it) and, thanks to their own first-hand learning experiences, presented ideas that were both plausible and in broad support of transit agency goals. Our guest experts were impressed both by the thoughtfulness of their solutions and their clear grasp of the underlying problems.

Just a few working hours later, after a flurry of ideation, prototyping, and rapid feedback, each group had a compelling—though not necessarily novel—proposal for a reimagined transit network in San Marcos. Without overt persuasion, all of the solutions conformed in spirit and letter with the stated goals of Agenda 2030. One group, inspired by safe cycling infrastructure and urban nature trails, proposed expanding the local greenway network by installing bird houses and other elements of “surprise and delight” to encourage utilization. Another group, dispirited by inhumane bus infrastructure, proposed building new stops that would serve as multimodal transportation and information hubs: as well as providing free internet access—a concept which would, itself, encourage ridership—they would provide shelter, news, bus arrival information, and access to a bike-share docking system. A third group, noting the lack of safe pedestrian infrastructure in the downtown core, proposed closing-off several streets and creating a walkable public square around the historic courthouse. A fourth group proposed adding a bus rapid transit corridor to a major cross-town thoroughfare. Their solution smartly leveraged existing road infrastructure investments while delivering service standards of a streetcar. Although none of the solutions were especially groundbreaking or revolutionary, their ideas demonstrated a willingness to acknowledge that a different way of life was, at least, conceivable.

Workshop reflections

These projects were presented during a “mobility festival” co-sponsored by the City of San Marcos and several local transportation advocacy organizations. Each student group was provided a small table, where they could display research and conceptual artifacts while having conversations with festival attendees. Over the course of two hours, each group had dozens of conversations with hundreds of guests and gathered significant—and positive—public feedback. Some visitors were convinced (even hopeful) that these ideas had already been approved for implementation.

Keeping in mind that none of our students were transportation experts, and that many of them grew-up in remote suburbs not served by any transit at all, we were pleased that their solutions demonstrated a clear, empathetic understanding of the complexities of the region's transportation issues. Whether or not students would, themselves, utilize their own solutions is unclear—although, as we have followed the personal journeys of workshop participants, we have observed an impressive willingness to pursue professions and ways of living that differ greatly from those in Texas.

Workshop outcomes were assessed using a pre/post evaluation of design competencies. Immediately after being admitted to the program, students were asked to self-report their level of confidence in a few key areas, such as their ability to analyze problems that lack a clear solution, or to reframe their solution to a problem. At the end of the workshop, we delivered the same survey. For the most part, we find that confidence in design abilities tends to improve over time. But, in the 2021 workshop, and subsequent workshops, we have found that one key area tends to decline: confidence in presenting work before it is finished.

Perhaps, as workshop organizers, we ought to spend more time teaching oral presentation skills or providing more opportunities for prototype refinement. But, given their reliably excellent presentations throughout the week-long workshop, we suspect this decline signifies something important about the role of parallax in the design process itself. To speculate: when students engage with a problem experientially, they are more likely to encounter the unarticulated “reality” of their design challenge: the gap between their own knowledge and prior experience, and the necessity of unanticipated remedies, expressed through unfamiliar ways of living. We believe it is possible this gap manifests in a growing hesitancy, which acknowledges the complexity of underlying problems, and the uncertainty of final and fixed solutions.

The concept of an inherently unresolvable parallax exemplifies the inevitability of conflicting perspectives—parallax is not something we should aim to eliminate, but rather understand and even leverage. This became clear in our workshop, where “pure difference” manifested in several ways. On one level, there was an intra-subjective parallax, highlighting the transformation of participants from their initial selves to those who could at least temporarily “be differently” in the world. On another level, an inter-subjective parallax emerged, underscoring the insight that, beyond individual preferences, it is possible to identify solutions that serve shared interests even while we, ourselves, might not utilize them. In that sense, the relative novelty of new bus stops, transit corridors, or greenways is only a minor consideration. (Re)discovering solutions that advance the broader sustainable development agenda is ultimately what matters.

Conclusion

In this paper, we have explored how design thinking might serve as a crucial mechanism for confronting important challenges posed by the United Nations' Agenda 2030. We posit that design thinking may function not merely as a strategy for developing novel outcomes or consumer products, but as a tool that can help us face the growing parallax that defines our current cultural and historical moment—and keeps our communities divided.

Design thinking, conceived as a tool for community engagement, provides a venue that encourages us to work across our differences, rather than trying to resolve them. This adaptation not only embraces as an asset the immediate challenge posed by the inclusion of diverse perspectives, but it also lays a foundation for the kind of engagement

that will be critical for achieving important sustainable development goals. Nonetheless, the scope and potential limits of design thinking are far from clear, and better assessment schemes need to be devised. Looking ahead, we believe it is important to extend design thinking research to identify areas of greatest impact. Of particular interest to us is whether direct engagement with change initiatives, facilitated through a design thinking framework, improves local acceptance and promotes durable change.

As we wait and watch “History” resume, we believe strongly that working across the parallax—strategically and purposefully, with everyone in our community—is essential for creating a bright and hopeful future. Indeed, rather than ending, perhaps the story of design thinking is just beginning.

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Who Framed the Government Architect?: Cultural residue, and a role for design in reshaping organizations

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ABSTRACT

There is a growing realization that change is required in order to meet the significant global challenges that we are all facing. Concerted efforts are being made globally to set measurable targets and goals (for example, the United Nation's Sustainability Goals, and the Paris agreement). However, at the organizational level we know that organizations are difficult to change, indeed organizational resilience is often celebrated. In this paper we review a design project conducted in 2013 where a Design Thinking workshop helped to catalyze radical transformation of an organization. We draw on this case to reflect on how design approaches can contribute to radical innovation.

Keywords: Reframing, radical innovation, design practices

1. Introduction

The central question of DTRS14 is "what role could design play in the shaping of sustainable futures?". As a contribution to this discussion, this paper offers a case study of radical transformation in an organization. We reflect on why radical transformation might be required in an organization, and the utility of the type of "Design Thinking" that this paper contributes to.

Cross recently drew distinction between two main streams of Design Thinking (from Cross 2023) and pointed to a third:

- 1 "DesignThinking 1"; coming from studies of designers in practice
- 2 "DesignThinking 2"; coming from the application of Design Thinking into business applications
- 3 Design Thinking emerging "as a way of acting within complex, problematic issues" (ibid).

This paper is temporally and conceptually situated within the emergence of this third type of Design Thinking. It is a case study beginning in 2013 at the Designing Out Crime Research Centre, which was mandated to draw on design in order to develop ways of engaging with complex societal issues. Whilst the case study is previously unpublished, on reflection this project not only had a large impact on the organization at the focus of the case study (the NSW Government Architect's Office), but also significantly contributed to research centre's contribution to this emergent application of Design Thinking.

2. Why does this really matter?

Organizations are established at a certain place and time. The dominant thinking of the time, and the cultural practices can be observed and felt even 200 years later. This phenomenon was termed “cultural residue” by Foucault (1972) and it can keep a business model in place even in light of evidence that the business model is ineffective, counterproductive and even harmful to society.

This plays out in many contexts, in this section we draw on an adjacent body of work from the Designing Out Crime Research Centre to illustrate how this cultural residue can limit an organization’s capability to innovate.

Cultural residue can be clearly seen in the criminal justice systems of some Anglo-Saxon jurisdictions, in this case the Australian state of New South Wales. Hugill (in Dorst, Watson, Doran (eds.), 2025) outlines how cultural practices manifested in rituals in the NSW Prison system date back more than 200 years to the British Royal Marines. The rituals that play out at formal dinners (such as “the passing of the port”) point to an organization (Corrections NSW) that was formed in the Napoleonic era, with rituals that even pre-date that time. These rituals point to embedded practices that are resilient, and counterproductive (given that one of the goals of incarceration today is rehabilitation).

This embedded thinking determines the very environment and culture of prisons and their workforce, which leads to “stark, minimalist and paradoxically problematic prison environments” (Lulham et al. 2016). The stark reality of the prison system in NSW is that people who go to prison are more likely to reoffend than people who are diverted into non-custodial rehabilitation programs (for example see, Wang & Poynton, 2017).

This matters because if our institutions remain fixed in their initial paradigm (and the practices of that paradigm), underpinned by the cultural residue of the times they were established, how can we expect the vastly different outcomes that are required to respond to the challenges of shaping sustainable futures?

When an institution’s innovation maturity seems limited to ‘incremental’, as in the NSW prison system (Lulham et al., 2016), there can really be no genuine expectation that an organization will achieve anything but outcomes that are at worst, business-as-usual and at best incremental innovations. This organizational ‘arrested development’ that confines innovation to ‘core’ (incremental), precludes ‘adjacent’ and ‘transformational’ innovation (Nagji & Tuff, 2014), limits the possibilities of an organization’s innovation portfolio. This then limits the potential for the type of systems change that is required to meet contemporary demands.

The risk then, is that organizations suffering a similar arrested development in innovation maturity will commit to the Sustainable Development Goals (SDGs), and then in submitting their annual SDG report they will frame their current actions relative to the SDGs. In so doing, the organization is only really reporting on what they were already

doing. Framing business as usual relative to new metrics (such as the SDG reporting), is not the same as changing business as usual in order to achieve different outcomes.

Why does this really matter? With current trajectories we are doomed. Simply measuring what we are currently doing relative to the SDGs smells of pretense, and places institutions who partake in this 'SDG washing' as complicit with the demise of the world. They are actively participating in a "collective suicide" (Grayling, p12, 2023). If we are not cautious Design Thinking may be complicit in this trajectory.

We will see in the case study that in order to achieve radical innovation of an organization, a first step is to suspend attachment to the current business model. This then allows deep engagement with understanding the value(s) the organization is intending to bring to the world, and an exploration of how else these values could be created and through what actions. Through this abductive logic (see Dorst 2011, Dorst & Watson, 2023) we can strategically engage with the challenge, with Design Thinking methods scaffolding the conceptual pathway from each state of thinking.

3. Methodology

This paper is part of a broader retrospective of key case studies conducted by the Designing Out Crime Research Centre that trace the development and impact of more than a decade of work. This paper is informed by public-policy centred, autoethnographic methods (Mosse, 2006) by a first-hand insider to the case study. This has included documentary analysis of the first author's notebooks from 2012 and 2013, the workshop agenda, workshop report, email correspondence over 2012, 2013 and 2014, media reports from the time, and public documents that demonstrate the emerging practice of the new Government Architect's Office.

The broader research that this paper contributes to will draw on interviews with participants in the case study, and a workshop with the lead facilitator and others involved in the case to compare notes and sense-make. In this sense this paper is an opening piece that will be built on in upcoming research publications.

This case study is situated within a broader body of work that was being undertaken at the Designing Out Crime Research Centre at the University of Technology Sydney. The Designing Out Crime Research Centre had a broader mandate from the Department of Attorney General & Justice to not just engage with projects through design, but to create new ways of taking on complex social issues. This mandate came from a realization from leadership at the Department that the current paradigm of knowledge and practice in criminology wasn't serving practice effectively. Crime prevention theory, wasn't providing adequate, actionable, knowledge to practitioners. Something different was needed, and that gave the Research Centre the opportunity to develop a new way of working.

After five years of development, by the inception of the central case study of this paper, the centre had demonstrated its impact at the project level (see Camacho Duarte et al.

2011, Lulham et al. 2012, for extended contemporaneous case studies) and at the conceptual level (Dorst 2011, Dorst & Tomkin 2011). Work was underway to share insights with an international conference in late 2012, a special issue journal (Asquith et al., 2013) and culminated in Dorst's theoretical exploration of Frame Creation in *Frame Innovation: Create New Thinking by Design* (2015), and the case study and methods focused *Designing for the common good* (Dorst et al., 2016).

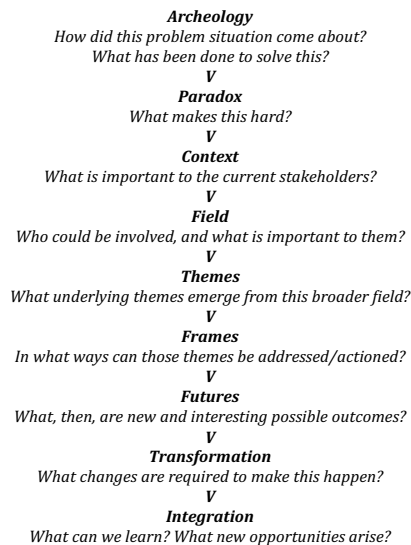


Figure 1. Frame Creation (Dorst, 2015)

At the time of this case study the Research Centre was in a crucial time in the development of its distinct style of 'Design Thinking'. The team had been working together on projects for several years, and now there was a distinct focus on engaging conceptually with the development of a way of working, underpinned by Dorst's Frame Creation (2015). For more on the methodological development of the Research Centre see Watson (2013) and Tomkin & Watson (2013). At the same time, the Research Centre was beginning to explore how these insights could be taken into other contexts (beyond crime). Which brings us to the case study.

3.1 Framing the Government Architect

In 2016 the NSW Government Architect's Office celebrated its 200th anniversary, making it one of the oldest Architectural practices in the world. The form and function of the office has changed over this time and relative to the circumstances it existed within.

In 1812 Francis Greenway was convicted of forgery in England. He was transported to NSW to serve his sentence through labor. His skills as an architect surfaced and in 1816 he was appointed as Colonial Architect, thus becoming the first NSW Government Architect. His tenure coincided with a period of growth in the colony, and to this day some of his works remain. There had always been a focus on 'public' buildings and

infrastructure from the NSW Government Architect's Office, so Greenway and many of his predecessors have a large physical legacy in the built environment in NSW.

Since 1816 the role of the Government Architect has shifted across the broad portfolio of architectural practice, often with a specific focus (designing buildings themselves, running design competitions, project management, commissioning tenders, reviewing public infrastructure, bureaucratic administration, etc.). At the beginning of this design project, the 23rd Government Architect (Peter Poulet) had recently been appointed. He had arrived at an office in the form of a government owned, commercially run architectural firm (competing against private sector firms for government tenders), that also had advisory and statutory functions (Keniger, 2013).

"Since its establishment in 1816, the NSW Government Architect's office has weathered many changes in political will, and of late has anchored the creation of new positions in other states. It is charged with advisory and statutory responsibilities, which ensures an ability to influence its government's policies concerning the built environment." – Keniger (2013)

The new Government Architect had a mandate from the government to reform the Office in order to become a body that could shape government policy in the built environment. The exact form and function of the new office were not determined by the government, but the business model (government owned architecture firm) had become dated, and misaligned with the government of the day.

In mid 2012, the Government Architect and the Director of the Designing Out Crime Research Centre met at a convention, and discovered that they shared a common path. In late 2012 conversations began between members of the Government Architect's Office and the Designing Out Crime Research Centre to explore a collaboration that would explore the utility of 'Design Thinking' for the Government Architect. Members of the Government Architect's Office attended the Design + Crime Conference (Asquith & Kaldor, 2013) to see the 'Design Thinking' approach in action, and to participate in live case study workshops demonstrating and exploring the Frame Creation approach.

By early 2013 an opportunity presented itself to apply the fledgling Frame Creation/'Design Thinking' approach to the Government Architect's Office itself. There was a starting point that the current form was outdated, not fit for purpose, and no longer supported by the Government. Change was needed and the Government Architect was seeking to engage people from his office in conceptualizing the future form of the Government Architect's Office.

Analysis of media at the time points to a deep vulnerability of the role of Government Architect in Australia:

"if they are not considered essential to the shaping of government policy, the advice and recommendations arising from such targeted advocacy may be readily dismissed as merely cosmetic. This vulnerability has been revealed in those states where the viability and effectiveness of the government architect's role has already been eroded and whose viability is a continuing concern." (Keniger, 2013).

With this narrative in the media there was clearly a unique set of circumstances, where things that had been solid, were now fluid. There was a mandate from the government to change, and a broad recognition at a sector level that the viability of the role itself was under question. We offered a process of exploring how the Government Architect's Office was presently framed, and a method of reframing the office, with people from the office itself.

The lead facilitator, Professor Dick Rijken was visiting the Designing Out Crime Research Centre to run a series of knowledge transfer activities. The first of these activities was to be a three-day workshop with the Government Architect's Office led by the facilitator, with the author documenting and assisting.

Introduction session

The workshop began with the Government Architect contextualizing what the aim of the workshop was, painting a clear picture that change was upon them, and that they had agency within that change to shape the future of the Government Architect's Office. The Government Architect had the mandate to shape government policy in the built environment, and this could not be achieved solely through being excellent architectural practitioners. The business model needed to shift.

GAO Design Thinking Workshop-Agenda February 2013

Monday	Tuesday	Wednesday
11.30-12.00 GAO and Design Thinking- Introduction to workshop - The value of Design Thinking & aims of workshop - Introductions - Discussion of workshop aims 12.30-2.00pm Introduction to design thinking (session open to architects/ landscape/ heritage)	9.30-4.30 Theme analysis, exploration and presentation, and frame creation Tuesday's focus is on identifying themes that emerge from Monday and the homework exercise. Second part of frame creation process where we generate new ideas about how GAO could operate	9.30-4.30 Frame elaboration and working towards MOU with UTS The focus of this day to be on the development of concrete outcomes based on the frames generated on Tuesday: - Articulate who we want to be and make a plan for how we will get there - Identify how GAO is/will be different to other design practices - Identify who our clients be - Plan for how we going to deliver on the promise of being strategic - Identify how we will improve ourselves and how we will improve service we offer people of NSW - Identify tasks and timeframes - How would UTS/GAO partnership work
2.30-4.30 Stakeholders analysis, problem arena, identification of themes The afternoon session is the first part of frame creation process-looking at GAO-what we are and where we want to be		

Figure 2: Workshop Agenda: February 19, 20, 21, 2013

An introduction to 'Design Thinking' included examples of how the Research Centre had been developing its approach, and examples of where it had been used. Several of the workshop participants from the Government Architect's Office had attended Design +

Crime in 2012, and so had participated in at least one workshop utilizing Frame Creation. The introduction given by the lead facilitator set the scene conceptually. In conversations with the Government Architect and team members in the lead up to the workshop it was clear that the Office had a solid culture, and that it would be necessary to think outside of the cultural boundaries that had emerged. Figure 3, which is taken from the workshop report and the author's notes, gives a summary of the conceptual ground covered in the introductory talk.

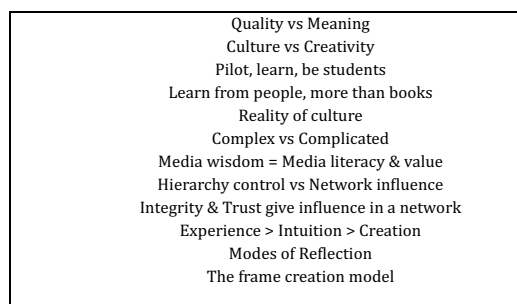


Figure 3: Conceptual Introduction, Lead facilitator, 2013

This conceptually rich starting point, made up of a collection of concepts and principles was aimed at providing a cognitive space where participants were tasked with setting aside how things are currently. This was an invitation to think with some of the concepts, such as “Quality vs Meaning” providing a pushing off point from what currently is, to what could be.

“Quality” holds a certain space within discussion on the built environment, however if we consider that the built environment exists in order for people to create “Meaning” in their lives, then we should start with an understanding of the desired “Meaning”, and how can that meaning be supported by the built environment. Quality then becomes a requirement, rather than a conceptual starting point.

This exploration of the first concept illustrates a setting of the scene to allow for Abductive thinking. It has opened up the “What” and “How” variables and placed “Meaning” in the why variable. The twelfth item in Figure 3 refers to the Frame Creation model that would underpin the flow of the workshop. The Frame Creation model is outlined in Figure 1, above.

Archeology and Paradox

We have spoken earlier in this paper about the broader history of the Government Architect's Office, and the deep vulnerability of the role of Government Architect in NSW at the time, which accounts for the ‘Archeology’ of frame creation. In this session the lead facilitator explored the ‘Paradoxes’ and challenges that were holding the Government Architect's Office back from seeing the change that was needed.

The following sections are direct extracts from the initial workshop report written by the author at the time of the workshop, along with reflections.

Paradoxes:

- There is an opportunity for the emergence of a change agent in Government, **BUT** we don't know how to become that change agent.
- We want to change, **BUT** we sit within a government agency that is slow to change
- We want to enable ourselves to be independent, **BUT** we sit in an agency and need permission.
- We want influence and power, **BUT** we are only the Government Architect.
- Society needs a professional organization that formulates visions from their (society's) point of view, **BUT** that organization does not exist.
- We are designed to serve the public, **BUT** we rarely consult the public.
- We are not competitive, **BUT** we force ourselves to compete.
- We are reliant on being commercially viable, **BUT** what about the public good?
- We want to be strategic, **BUT** we have no control or authority.
- We think we have important things to say, **BUT** we are not heard.
- We get satisfaction for making/doing, **BUT** our clients/peers think they are the ones doing the thinking.

Reflection: In Frame Creation, paradoxes often present themselves as unresolvable contradictions. The exercise of naming the paradoxes was seen as a cathartic exercise, and also an exercise of identifying the complexity of an issue. At this point in the development of our approach, we were at pains to make it explicit that we would not be seeking to directly address the paradoxes, but we would come back to them later, after we had thought more broadly.

Context

We moved on to exploring their current stakeholder group where the question was asked; 'who are the organisations, or departments that you work with?' This elicited a list of 28 stakeholders, across categories including, public service organisations, organisations within the built environment ecosystem, citizens, communities and special interest groups, and education providers.

Reflection: In terms of facilitation, it was important to send the group home on a hopeful note. The archaeology and paradox activities can lead to a deep introspection, and sometimes a sense of hopelessness. A sort of "we've tried everything and we are still stuck". Or in the case of the Government Architect's Office, a sense that they are misunderstood and undervalued. By ending the day with an analytical exercise of listing stakeholders, the participants were asked to form the mindset of "ok, what have we got to work with here?"

Field

Participants were divided into pairs and asked to select 3 stakeholders. The pairs were given 45 minutes to explore the stakeholders and report back to the main group with:

- Name of entity
- What we think their perception of the Government Architect's Office is
- What we think their agenda is
- What problems do we think they are facing?

Conceptually the mindset that participants were asked to take in this exercise was one of “if we are misunderstood and undervalued, then what do our stakeholders actually need?”

Upon returning to the workshop, the pairs each gave their responses, while their answers were summarized on flipcharts and stuck to the wall. Participants were then facilitated through an analysis of what was reported back. Here are the common problems across the stakeholder group:

- Instability
- Those with power don't know how to use it, or don't know their problems
- Empowerment
- Everything is in flux
- Powerless
- Everyone is in survival mode
- Want design excellence, but it seems to be an abstract term

Theme identification

The group then were asked to characterise the above commonalities, which are common problems or aims, through a single meaningful word:

Design excellence	Instability	Empowerment
Vulnerability	Powerless	Potential
Political influence	Identity	Ambition
Beauty	Quality	Flexibility
Resilience	Adaptability	Inert
Caring	Nurturing	Aspiration
Insecurity	Recognition	Pride
Expertise	Authority	Vision
Passion	Influence vs Power	Complexity
Creativity	Dependence	Independence
Innovation	Relevance	Expression
Reflection	Provocative	Curiosity
Purpose	Cohesion	Honesty
	Accountability	Diversity

Figure 4: Theme Identification

Theme exploration

The themes were then put together in to clusters by the group. Discussion on each cluster and how the individual themes related to each other and how they relate to the Government Architect's Office. The clusters are below, with the reflection on how they relate to the Government Architect's Office below them in bold type.

Relevance	Value	Identity
Political Influence	Dependence	Authority
Honesty	Influence	Expertise
Accountability		Trust
Independence	Resilience	

Reputation

Figure 5: Theme cluster 1.

Reflection	Design Expertise	Beauty
Character	Quality	

Output

Figure 6: Theme Cluster 2.

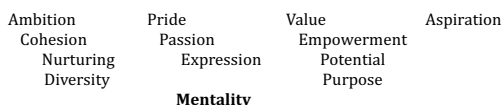


Figure 7: Theme Cluster 3.

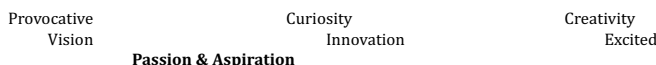


Figure 8: Theme Cluster 4

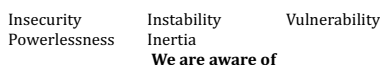


Figure 9: Theme Cluster 5

Reflection: In order to move into a positive and generative mindset, Figure 9 became a place to park elements of the paradoxes that resurfaced through the theming exercise. This gently facilitated “look over there” was crucial at this point, as there was a danger of falling back into the deep introspection that occurred in Session 2. The desired mindset now is one of being abstracted away from the current form of what is, and to then use the theme clusters as inspiration to reframe.

Frames

The six clusters were distributed to the pairs who were sent for coffee for 1 hour to discuss the meaning of the themes in relation to the Government Architect’s Office. The pairs were asked to identify the most important theme from the cluster, and to create a number of working frames. The question was asked; how can the Government Architect’s Office embody these themes?

Six frames were created. The frames are in bold, with the notes from the pairs description of the frames following:

Vulnerable Power

Know your weaknesses and agree on a direction. Identify how your stakeholders are vulnerable. Step away from ‘we always know what we’re doing’. This is a mentality rather than a skill. Set up a course of action to acquire that mentality. Knowledge > Skills > Mentality

Respectful Honesty

Its like ten-pin bowling. Adaptability and flexibility are the pins. The balls are complexity. The arm is resilience. Other organizations are more adaptable than the Government Architect’s Office. Our current notion of resilience may be limiting. The phoenix vs the butterfly. Nuance and diplomacy.

The way we deal with risk. Critique will cause criticism. How do we take a hit? We’re experts and should demand respect. There’s 2 ways to deal with that. Be Teflon, or be a stick in the mud.

If we network, then when one part goes down the rest will survive and cover the gap. If we were Greenpeace then we could be a stick in the mud. We need to be clever in the way we work. Like political advisers. Experts in their field but single minded.

Internal Mentality

Caring. It is a selfless act. It's dirty, but it's achieving a common good. Communication (listening to understand). Client relationship is important but not as important as the end user. Can be prescriptive, but should be open. WE are servants to the public. Need to be flexible, intelligent, reinterpret what's required. Focussed on individual. People need a hug. Understanding ground rules. "I care about what you care about". Conflicts can come back to shared ground. Internal care leads to a reflection of care in outputs. Care is love, sacrifice, empathetic, grounded in shared values. Allows an openness, open to learning, interaction with clients. Can be challenged.

Passion & thinking

Innovation holds it together. Curiosity – openness and naivety. Provoking. Stimulating to create something new. Vision identifies goals. Innovation = analysis of precedents, context, create new audience. An attitude or collection of attitudes. An artistic mentality allows openness. Understanding what public needs. Openness. Ok to innovate. Open is boundless. Curiosity is endless.

Nuance and diplomacy

Change the assumption from the Government Architect's Office as a builder to Government Architect's Office as a think tank. Outputs create knowledge. Disseminate, integrates design excellence. The things that are output are reflections of quality. Who do we do this with? Experts and experimenters (universities), a random (resident poet), duty holders. Consciousness and discussion.

Catalyst

Not to kill the old, but to grow to something new. The Government Architect has been around for 200 years. Oldest arch firm in the world. Embedded in legislation. Embrace the history. Embody history. Embody the values of NSW people. Leadership. Do? Advise? Not mutually exclusive. The Government Architect's Office to be a good critic. A think tank. Mentor, influence and inspire. Not claiming authority (Catalyst was generated at this point).

Futures

Participants were then asked to consider, based on the frames, by thinking about 'who do they want the Government Architect's Office to be', and to make a plan on how to get to that identity. Participants were asked to consider how they will be different to other design practices, who their clients would be, how will they deliver on their promise to being strategic, how they will improve themselves and the service they provide, to identify tasks and timeframes.

4. Re-Framing the Government Architect

From the six frames that emerged through the workshop, three of them stood out as helping to establish a new framing of the Government Architect's Office.

- Keep old, grow new, which evolved to 'celebrate old, create new'
- Phoenix
- Catalyst

The Government Architect's Office would become a strategic thought leader in the built environment. An exhibition (State Library of NSW, 2016) celebrating 200 years of the Government Architect would be held **celebrating** the legacy of the old form of the office. The Office itself would soon close, and be reborn in a new form (**phoenix**) as a **catalyst** for excellence in the built environment.

Following the workshop the Government Architect's Office and the University of Technology Sydney established a Memorandum of Understanding, and for the next few years worked together to:

- Develop interest and awareness of 'Design Thinking' in the NSW Government.
- Build the Government Architect's Office in using 'Design Thinking'.
- Collaborate with clients utilizing 'Design Thinking'.

Through this partnership the Government Architect's Office and the Research Centre were invited by the Secretary of the NSW Department of Premier and Cabinet to give a briefing to department heads on 'Design Thinking'. The NSW Public Service Commission invited them to run the 'Design Thinking' component of their Innovation Leadership Development Program, which continued across multiple years, catalyzing post graduate programs. Members of the Government Architect's Office embedded with staff from the Research Centre on many projects utilizing 'Design Thinking' (see for example van der Bijl-Brouwer et al., 2015).

5. The new form

By 2016 the Government Architect's Office had moved from Treasury (public works) to the Department of Planning. By building innovation capability through the NSW Public Service Commission's Innovation Leadership Development Program, and by engaging strategically with government partners through projects that utilized 'Design Thinking' the Government Architect's Office had ceased to be a government owned architecture firm, and had strategically engaged with the architecture of government.

"jobs have been cut from 120 to four, and the office has been moved from its old home in Treasury to the Department of Planning and Environment where the current government architect Peter Poulet will relaunch a new type of government architectural practice with a different role from the past." (Power, 2016)

Still primarily focused on the built environment, the Government Architect's Office went about rebuilding into its strategic function. This is embodied by:

- Better Placed; an integrated design policy for the built environment of NSW (Government Architect NSW, 2017)
- Sydney Green Grid; A network of high-quality green space that connects town centres, public transport hubs and major residential areas (Schaffer, 2015)
- The Ochre Grid; Developing a stronger presence for Aboriginal culture in the planning system led by Dylan Kombumerri (GANSW, 2020, Russel, 2022)

This shift took place over a number of years and became the new business as usual. The history of the role was celebrated with an exhibition (State Library of NSW, 2016). The team has been rebuilt around this function, and at last visit had regrown to 30+ people. Ten years on we can see opportunity for further research in to this organizational transformation.

8. Discussion

On the DTRS14 theme of the role design could take in the shaping of sustainable futures, this case study offers a historic, yet previously unpublished case study of how 'Design Thinking' has been used in radically innovating an organization. Based on these reflections there are some key insights that can be drawn out in this paper.

1. In this instance there was a top down mandate to change. 'Design Thinking' was used to facilitate a bottom-up process of forming the change. - Change is coming, shape the change or be shaped by the change.
2. 'Design Thinking' in this case was specifically used to facilitate Design Abduction. - Start with shared value, then establish shared/agreed principles, and then actions.
3. Pragmatically look at what your partners need. See the difference between what you offer and what the world is asking for. - Be brave. Stop doing what you are doing, in order that someone else may do it.

Stepping away from existing form, engaging conceptually and reframing towards a new form enabled the Government Architect's Office to escape their arrested development, and to develop new *modus operandi* to fulfil a new role within government. This radical approach led to a dramatic shift in the form, function and impact of the Government Architect's office. Thinking back to the NSW Prison System side-case, the NSW Prison System was formed at around the same time as the NSW Government Architect's Office. If it is to see a radical shift in its outcomes, perhaps this radical approach could be useful.

Further research into this case study is planned in order to draw deeper insights from a broader data-set.

Acknowledgements

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From Past Pandemics to Future Health Crises: A Systemic Design Framework for Building a Healthier Future

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ABSTRACT

The emergence of new viral epidemics remains a major public health and societal challenge, as demonstrated by the COVID-19 pandemic. One of the major challenges is to better understand the dynamics of outbreak patterns, interventions, responses, measures, public narratives, and people's perceptions and behaviors. The experience of past pandemics can provide valuable lessons for improving future pandemic management – a crucial step towards a more resilient public health strategy. We argue that "learning from the past" can help policymakers and society better prepare for the next pandemic or future health crises. Based on a systemic design approach, we propose a systemic design framework for developing innovative and sustainable strategies for future health crises. The framework ranges from "learning from the past" to future scenarios and includes retrospective and prospective analysis. The framework also takes into account socio-economic factors, and dialogues with different stakeholders and target groups. To develop the framework, we use two consecutive pandemics as case studies: the "Spanish flu" and the "Asian flu" in Switzerland.

Keywords: systemic design, learning from the past, pandemic research, public health

1. Introduction: Learning from the past

Public health continues to face a mix of familiar and new challenges in an evolving context. Drawing on historical knowledge and empirical data is essential to avoid repeating mistakes of the past and to increase efficiency, reduce costs and improve health outcomes. At the same time, it is essential to have a flexible toolkit to address the unforeseen elements and new context of health challenges, underscoring the importance of learning from both the past successes and failures (Staub, 2023). Leveraging both positive and negative experiences, and thus learning from history, whether it be recent

or from a more distant past, is indispensable in public health. But how can knowledge be effectively managed and transferred to the different stakeholders involved and future generations?

Infectious disease outbreaks are a prime example of how past experiences can inform current public health strategies. The COVID-19 pandemic highlighted the need to understand outbreak dynamics, public narratives, and behavioral responses to better prepare for future health crises. Analyzing historical pandemics provides invaluable insights for designing proactive and effective policies for the present and the future (Mamelund, 2021; Mooney, 2021).

Whenever new health crises emerge, there is a tendency to view them through the prism of past pandemics. The 1918 influenza pandemic, one of the deadliest outbreaks in modern history with 20-100 million deaths worldwide (Morens et al., 2021), is an example of a critical lesson that has been lost to “collective memory” over time, leaving societies less prepared for subsequent pandemics. This phenomenon, which we have termed the “pandemic disaster gap” (Staub et al., 2020) and which is particularly pronounced in Switzerland, reflects a general trend of diminishing historical awareness. The lack of recent pandemic experience prior to COVID-19, coupled with inadequate communication of lessons learned from past pandemics, has led to a disregard of pandemic risks among the population and policymakers. The resurgence of COVID-19 has underscored the urgent need to bridge the gap by reviving and applying historical pandemic lessons. This includes re-evaluating forgotten preventive measures such as mask use, hygiene, vaccination, and preparing for new variants. Our project “Bridging the Gap: Dialogues between Scientists and the Public, Policymakers and Journalists about Lost Past Pandemic Experiences” aims to use such historical lessons to improve crisis management – a crucial step towards a more resilient public health strategy.

Vulnerability analysis in crisis research emphasizes the importance of understanding societal exposure to threats and the capacity for resilience and adaptation. When a society faces a critical event that threatens both life and stability, understanding the specific nature of the disturbances it confronts is essential. Whether the critical event is caused exogenously or endogenously, it always encounters a temporally and spatially situated society with specific political and social traditions, specific experiences from the past, specific technical means, and horizons of thought to address the problem, and especially specific political procedures to negotiate possible solutions. An analysis therefore involves examining the types of challenges faced, their impact on societal structures, and the responses elicited. Specifically, exploring the “exposure” category requires a deep dive into how and to what extent a society is exposed and vulnerable to the threats (Krämer, 2016). Meanwhile, the “coping/resilience” aspect focuses on identifying and enhancing the methods a society employs to manage, adapt to, and learn from these disruptions. The ultimate goal is to reduce current and future vulnerabilities, foster adaptability, and bolster societal resilience. In this context, integrating lessons from the past is a critical element, underscoring the significance of historical insights in understanding and mitigating vulnerability.

The concept of “learning from the past”, however, is complex and requires a nuanced approach that takes into account both historical precedents and the unique circumstances of past and new challenges. History fails to offer immutable laws that persist through the ages (Condrau, 2020; Peckham, 2020). We conceptualize “learning from the past” as the extraction of insights from history, recognizing both its parallels and contrasts with the present (Morens et al., 2021), and recognizing that our view of history is inevitably based on interpretations of sources and influenced by our contemporary viewpoint. Within this concept the past contains both scenarios and warnings that can be adapted to a new challenge and context. For such learning to be meaningful, a bridge of knowledge must be built that connects historians with policymakers and society at large (Berridge, 2008). The risk of “retrospective diagnosis” poses a challenge to learning from the past, as it involves interpreting historical events through a contemporary lens, potentially distorting the lessons of history. This could imply that modern interpretations of health and illness are projected onto the historical context, even though past societies had different perspectives on these events. As a result, each generation reevaluates its history, leading to evolving interpretations of historical truths. Recognizing the relativity of historical interpretation is crucial to the accurate and useful application of past experiences through the process of “learning from the past” to current and future health challenges.

To circumvent the pitfalls of adhering too rigidly to past solutions and the status quo, Valencia et al. (2022) propose an evolved “learning from the past” approach. Their approach involves exploring disruptive systems within vastly different future scenarios, thereby expanding the horizon of potential solutions. They call their approach “learning from the future”, which means expanding “the search horizon of our future solution space beyond already well-explored drivers” (Valencia et al., 2022). The aim is to develop inspiring visions and identify transformative pathways for sustainable futures.

We argue that integrating lessons from the past can help to better anticipate and mitigate future health crises and specifically help to improve future pandemic management. However, in order for policymakers to make informed decisions, it is critical that past experience is integrated into a comprehensive framework that takes a holistic view of pandemics. “Holistic thinking” means: Perceiving a system by understanding its large-scale patterns. In the following sections, we propose a systemic design framework that aims to synthesize lessons from past pandemics (“Spanish flu” 1918-1920, “Asian flu” 1957) in Switzerland (as an example) with potential future scenarios to promote holistic and informed pandemic management strategies. Our framework relates to SDG 3: ensuring healthy lives and promoting well-being; and to the Agenda 2030: fighting communicable diseases.

2. Methodology and data

One of the main goals of this project is to derive recommendations for future actions in public health based on the knowledge gained from pandemic research. A key step in this process is to examine responses and adaptations to pandemics by examining how

governments, authorities, organizations and society have responded to previous pandemics. For example, what strategies have been used to prepare for health crises, and how have economic and social systems adapted to deal with the consequences of pandemics? Since lessons learned from the past cannot be linearly applied to the future, the project team is using a systemic design approach to develop a framework for building a sustainable future for health. The methods, tools, and design practices of our systemic design framework are outlined in the Sections 2.1–2.3; they are the building blocks of our framework we introduce in Section 3. In Section 2.4, we present our case studies: a data analysis of the “Spanish flu” and the “Asian flu” in Switzerland.

2.1 The systemic design approach

Our framework is based on the systemic design approach as outlined by the Design Council (2021, p. 47). It recognizes the interconnected, complex nature of challenges and prioritizes the environment as well as its people.

At the heart of the systemic design process is the double diamond, which represents divergent and convergent thinking and describes four design practices that are essential to any design and innovation process: explore, reframe, create, and catalyze (Design Council, 2021, p.45). We will explain the model and how we apply it later in Section 3. Systemic design allows us to look not only at the separate parts of the problem at hand, but also at how those parts are connected, to identify the various factors at play, to consider different perspectives, and to see how the system changes dynamically over time and how it relates to a larger context in its full complexity (Design Council, 2021; Gatterer & Tewes, 2023). In essence, thinking systematically enables us to act systemically. Adopting a systemic design perspective not only allows us “to see how a change or development of details affects a whole system” (Eriksson, 2022, vi), it also helps us to avoid the trap of linearity and to design solutions in an iterative and holistic way. It helps to navigate the complexities of learning from past pandemics and to design future scenarios that are placed in the broader context of complex and interconnected relationships (Gatteret & Tewes, 2023).

The systemic perspective in the framework presented considers past and future scenarios (Section 2.2) in combination with the four subsystems of society: politics, economics, legitimacy, and community (PWLG matrix, Section 2.3). It also takes into account different types of media.

2.2 Diagnosis, prognosis, regnosis

The first step in our framework is to conduct a multiperspective analysis (Fig. 1) consisting of three phases¹:

¹ As this is an ongoing project, we have only completed the diagnosis step and are now planning the prognosis and regnosis steps (current status: May 2024).

1. Diagnosis: looking at the present and back to the past taking into account the limitations and biases of a retrospective diagnosis as described in Section 1.

2. Prognosis: looking forward from the present to the future.

3. Regnosis: looking back from the future to the present.

Conducting a retrospective analysis based on research data from past pandemics provides a comprehensive **diagnosis** and understanding of historical and current patterns and, therefore, societal changes. On this basis, we aim to provide a forecast (prognosis) for dealing with possible future pandemics and to identify treatment recommendations for the future (regnosis). In contrast to **prognosis**, which looks from the present into the future and is tied to our knowledge and existing possibilities for action, the future becomes recognizable as something that can be shaped in the **regnosis** (Bozyazi, 2022). By projecting ourselves into the future, we create a bridge between today and tomorrow: an awareness of the future. We observe ourselves and look back and realize that we ourselves are the future.

The idea of **regnosis**, a term coined by Horx (2020, 2021), is to mentally jump into the future and look back from there to understand how we got there and how we can best be prepared for the predicted future. It follows the same idea as the backcasting method, in which a series of steps map out an action plan, starting from a vision and working back to the present (Valencia et al., 2022; Mangnus et al., 2019; Voros, 2006). Both backcasting and regnosis involve predicting future scenarios. However, while backcasting starts with a desired future state and works backward to determine the steps needed to achieve it, regnosis does not necessarily assume a predefined desired outcome. Instead, regnosis involves adjusting existing forecasts based on ongoing analysis and feedback loops. So, in our context of pandemics, the term regnosis is more appropriate.

MULTIPERSPECTIVE ANALYSIS

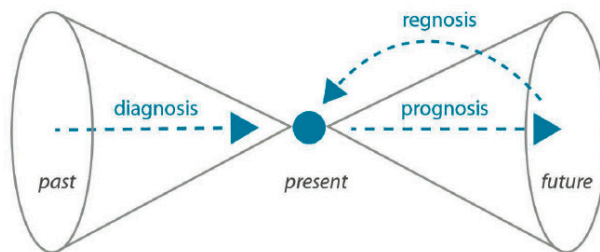


Fig. 1: Multiperspective analysis: diagnosis, prognosis, and regnosis

2.3 The PWLG matrix

To conduct a holistic analysis, we will use the so-called PWLG matrix² in all three phases of diagnosis, prognosis, and regnosis as an underlying matrix (Fig. 2). PWLG stands for four dimensions: politics, economics, legitimacy, and community. The PWLG matrix was introduced for research purposes by the Zukunftsinstitut³ and reported in detail by Gatterer & Tewes (2023). It was developed to uncover structural influences and understand the relationships between:

Politics: The political decisions and frameworks (measures, legislation, and political debates) taken during the pandemic. Here, we analyze how political frameworks have influenced the response to the pandemic.

Economics: The economic impact (economic structures, business models, innovations) in both the short and long term. Here, we analyze how the economy has responded to the pandemic and what organizational changes have taken place.

Legitimacy: The legitimation of measures (ethical, moral, and societal aspects as well as acceptance or rejection). Here we analyze how information was supported during the pandemic, and the rationales and justifications used.

Community: The cultural aspects of society (changes in values, lifestyles, social structures, and community relations). Here, we analyze how communities have interacted with each other during the pandemic and what social changes have occurred.

In addition, the PWLG matrix suggests four types of media. We will examine the four types of media to understand the coverage and discourse of megatrends in the context of pandemics.

Empirical media: Articles, reports, facts, and data published by researchers or research institutes during the pandemic.

Positioning media: The viewpoints and opinions of special interest groups (e.g., experts, unions, Think Tanks, advocacy groups) and their different perspectives as well as the impact on public opinion.

Application-oriented media: Publications (e.g., specialist journals, white papers) that provide practical applications of information and examination of how the advice and recommendations have been put into practice.

² PWLG is an acronym made up of the German words "Politik, Wirtschaft, Legitimation and Gemeinschaft". We use the original German name for the matrix here but refer to the individual dimensions in English (politics, economics, legitimacy, community).

³ Zukunftsinstitut website, "About us", <https://www.zukunftsinstitut.de/das-zukunftsinstitut> (accessed on Feb 12). The Zukunftsinstitut is known as a renowned partner for organizations and stands for resilient and applicable futurology. It transforms exclusive trend analyses and research results into concrete measures, comprehensive concepts, and effective strategies, understanding the future as a space for action.

Wide-reach media: The influence of wide-reach media (e.g., news sites, newspapers, radio, television, blogs) on public perception and reaction.

We will use the PWLG matrix as a tool for classifying and analyzing our data in the context of social change movements and for exploring complex interactions and relationships between different aspects of society in the context of pandemics.

PWLG MATRIX

A systemic approach to classifying and analyzing data in the context of social change to identify potential challenges and solutions.

	Politik <i>Politics</i>	Wirtschaft <i>Economics</i>	Legitimation <i>Legitimacy</i>	Gemeinschaft <i>Community</i>
Empirische Medien <i>Empirical media</i>				
Positionierende Medien <i>Positioning media</i>				
Anwendungsorientierte Medien <i>Application-oriented media</i>				
Reichweitenstarke Medien <i>Wide-reach media</i>				

Fig. 2: The adapted PWLG matrix (Gatterer & Tewes, 2023).

2.4 Case studies: “Spanish flu” and “Asian flu”

Diagnosis / data analysis: Over the past 150 years, the world, Europe, and Switzerland have experienced several epidemics and pandemics of respiratory infections: the "Russian flu" 1889-1894, the "Spanish flu" 1918-1920, the "Asian flu" 1957-1958, the "Hong Kong flu" 1969-1970, the "Russian flu" 1977, the SARS epidemic 2003, the "swine flu" 2009, the MERS epidemic 2012, and COVID-19 2020-2022 17,18. Prior to COVID-19, the 1889, 1918 and 1957 outbreaks were the pandemics with the greatest impact on health and/or mortality, with large differences between world regions.

In Switzerland, the "Spanish flu" of 1918–1920 remains the greatest demographic catastrophe of the 20th century. It is estimated that about 25,000 people died in Switzerland from this pandemic, with the long wave in the autumn and winter of 1918 being particularly deadly (Staub et al., 2022). Why, as elsewhere, the 1918-1920 pandemic virus killed so many young people compared with other influenza pandemics is not yet fully understood. Comparing the various pandemics in Switzerland since the late 19th century in terms of (excess) mortality from all causes of death, the "Russian flu" of 1890 caused about 3000 or 10% more deaths and the "Spanish flu" of 1918 caused about 25,000 or 50% more deaths than what would be expected based on the preceding five years (Staub et al., 2022). Subsequently, however, none of the global

pandemics between 1920 and 2020 reached the severity of the Russian or Spanish flu in Switzerland (Fig. 3).

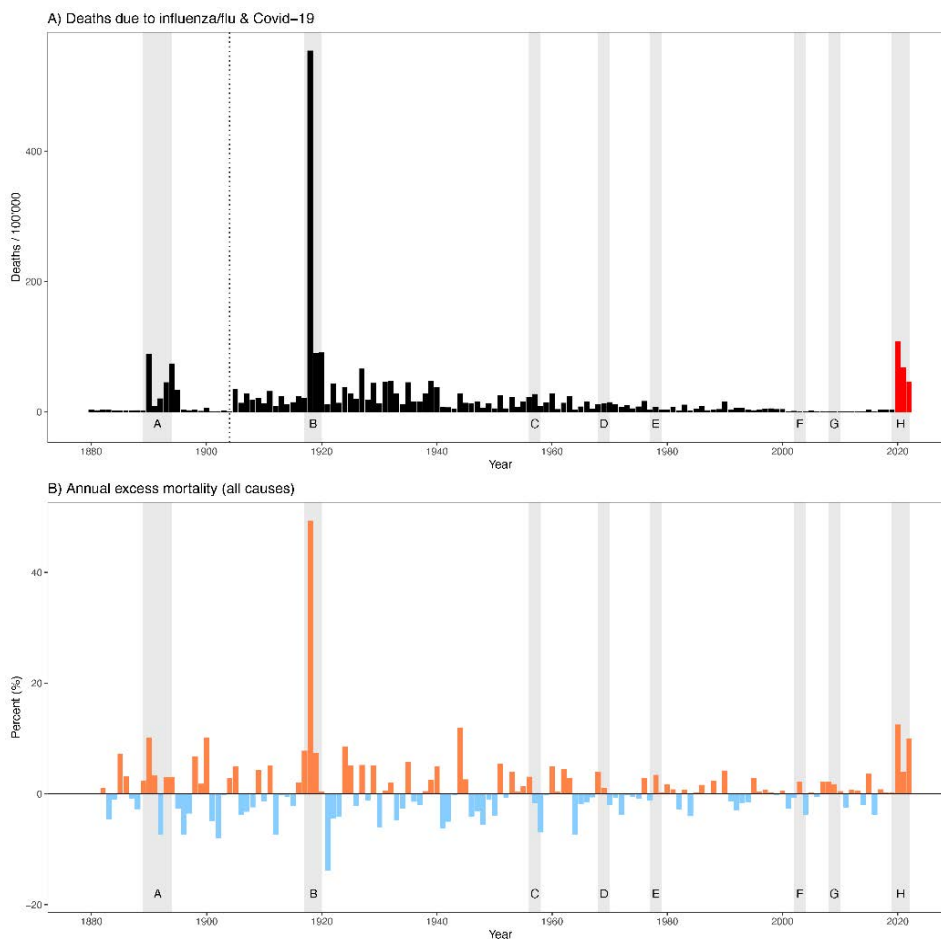


Fig. 3: The eight pandemics since 1880 (gray shaded bars) and their impact on mortality: A) Officially reported deaths per 100,000 population due to influenza as well as COVID-19; B) Annual excess mortality (all causes of death) in percent (red=excess mortality, blue=inferior mortality) according to Staub et al. 2022. Pandemics: A) "Russian flu" ca. 1889-1894, B) "Spanish flu" ca. 1918-1920, C) "Asian flu" 1957, D) "Hong Kong flu" ca. 1968-1970, E) "Russian flu" 1977, F) SARS 2003, G) "Swine flu" 2009, H) "COVID-19" 2020-2022.

Over the past decade, our goal has been to make these past pandemics in Switzerland more accessible again (Bernhard et al., 2023; Boser & Staub, 2023; Staub, 2021; Staub et al., 2021; Zwahlen & Staub, 2022). We have done this by digitizing data sets from archives that would otherwise be forgotten and making them available through an open research data hub (www.leaddata.ch). The data sets have been carefully selected, taking into account their strengths and weaknesses.

It is not only important to obtain mortality and morbidity data, but also to analyze media: the records of parliamentary and public debates, individual documents such as diaries and letters, and newspaper articles. In order to gain a more comprehensive understanding of the social, political, and economic conditions during the pandemics, we have started to collect personal stories, i.e. to interview contemporary witnesses or their descendants about their personal or social experiences during the "Spanish Flu" and the "Asian Flu" in Switzerland. For the interviews, we use a mixed approach of journalistic and oral history elements – oral history and journalism both contain interview traditions that are similar but not identical (Feldstein, 2004). The interviews (recorded as audio or video) will serve as one source among other sources to produce data stories that will be made available to the public (www.leaddata.ch). All findings of our project will be synthesized and presented to key policymakers and government officials for discussion.

Prognosis and regnosis: The next step in our ongoing project will be to conduct stakeholder interviews with policymakers, representatives of authorities, and special interest groups in the health sector to examine how organizations, governments, and society as a whole have responded to past health emergencies and pandemics, with the goal of identifying pathways of knowledge transfer and "lessons learned" and gaining insight into questions such as: How are lessons learned recorded by the authorities? How are plans for health crises evaluated once the crisis is over? How does the transfer of knowledge take place over time? The aim here is to discuss and better incorporate lessons learned into future pandemic scenarios.

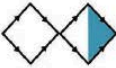
3. Results: A systemic design framework for building a sustainable future for health

To bridge the gap between the lessons from the past and the learnings for the future, we go beyond the retrospective and forecasting analysis by developing a systemic design framework. Our framework is intended to help people meet the challenges of future health crises and design sustainable solutions. Figure 4 illustrates the framework that incorporates the steps and phases described in Section 2. The framework visualizes all phases and steps in our project. However, we have not yet completed all phases of the project. Table 1 shows which specific activities and methods have already been carried out for each step in the process (✓) and which are still being planned (□).

Furthermore, it should also be noted that the framework has not been evaluated yet. It is used as a prototype within this project to combine systemic design thinking and traditional scientific methods.

Table 1: Applied or planned methods in each step of the framework

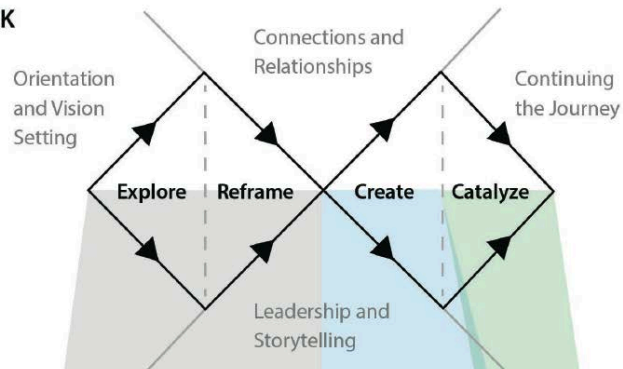
DESIGN ACTIVITIES

Explore	Digitizing and analyzing large quantities of historical pandemic data:
	✓ Interviews with contemporary witnesses (video recording) ✓ Data analysis and aggregation on the LEAD website ✓ Analysis according to the PWLG Matrix
Reframe	Identifying challenges and opportunities in the collected data:
	✓ Information hub setup (www.leaddata.ch) ✓ Stakeholder mapping (actors map) □ Analysis according to the PWLG Matrix
Create	Conducting workshops with stakeholders to help them articulate the shared desired future and intended value creation:
	□ Citizen panels □ Delphi method □ Scenario analysis □ Regnosis □ Analysis according to the PWLG Matrix □ Developing possible intervention strategies
Catalyze	Deriving recommendations for actions based on analysis:
	□ Knowledge transfer to practice and relevant stakeholders □ Identification of actions and recommendations □ Dialogues between scientists and the public, policymakers, and journalists about past pandemic experiences □ Further development of the information hub (www.leaddata.ch)

The first diamond consists of the design practices “**Explore**” and “**Reframe**”, which are embedded in the sector “**Orientation and Vision Setting**”. In our case, this sector stands for systematic scenario analysis; it limits which insights are relevant and usable and which are not. The starting point is our previous research (www.leaddata.ch), which aims to help bridge the knowledge gap about past pandemics in Switzerland.

SYSTEMIC DESIGN FRAMEWORK

Using systems thinking for pandemic challenges offers holistic solutions that take into account the needs of all stakeholders and the dynamics of the system.



MULTIPERSPECTIVE ANALYSIS

Diagnosis:

Analyzing past pandemic data to identify historical and current patterns of pandemic situations.

Prognosis:

Co-creating with present stakeholders. Gathering experiences and developing future scenarios.

Regnosis:

Developing recommendations for actions. Based on future scenarios, necessary steps back to the present are outlined.

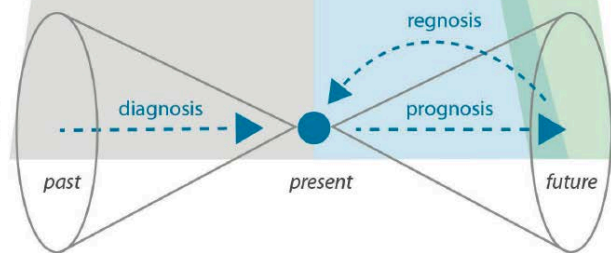


Fig. 4: Systemic design framework with the double diamond and the three phases: diagnosis, prognosis, and regnosis.

In the “**Explore**” phase, we collect information and digitize data on the pandemics under review, aiming to understand the challenges of each pandemic. Following the systemic approach, we structure the information and data along the **PWLG matrix** to determine comparable influencing factors. The goal of this **diagnosis phase** is to delve into the existing system by reviewing different sources and considering all relevant aspects. In the “**Reframe**” phase, systematic interactions and connections are determined based on the PWLG matrix, and relevant influencing factors for the various stakeholders are defined. The framework allows the comparison of data from different sources (e.g., collected knowledge from long past pandemics, interviews from the Covid pandemic). The goal of this phase is to synthesize insights and identify specific opportunities or challenges (Design Council, 2021).

The second diamond consists of the “**Create**” and “**Catalyze**” phases, which are embedded in the sector “**Continuing the Journey**”. It focuses on the dynamic system which stands for incessant changes and newly emerging possibilities (Design Council, 2021). In the “**Create**” phase, a comparison of relevant influencing factors is made. Furthermore, we define strategies and areas of action together with stakeholders as the framework provides guidance for dialogues (e.g., in workshops) with policymakers to address pandemic challenges. The idea here is to use the knowledge from the systemic retrospective diagnosis for the **prognosis** of optimized solutions for decision-making in the future. Building upon lessons learned, the next step is to make future predictions for managing potential pandemics and to develop new desired solutions to the problems (regnosis). Finally, in the “**Catalyze**” phase, we deliver our insights and findings to the different target groups in public events, videos, and data stories on the information hub (www.leaddata.ch). The two sectors “**Connections and Relationships**” and “**Leadership and Storytelling**” involve dialogues between scientists, different stakeholders and target groups, and the transfer of knowledge to society at large.

4. Conclusion

Based on a systematic design approach, our framework integrates various design methods and practices to develop innovative and sustainable strategies for health policy in Switzerland and beyond. We apply the core of systemic design by asking ourselves not only what we can learn from the past, but also what this will teach us for the future. The developed framework visualizes how we understand the concept “learning from the past”: as a holistic, systemic-centered, non-linear, and future-oriented concept. System thinking offers solutions that are more holistic and take into account the needs of all stakeholders while understanding the dynamics of the system.

The application of the framework requires a multidisciplinary team with experts from different fields such as public health, historical epidemiology, politics, economics, sociology, design, and technology. It can encourage dialogues between the scientific community and the various stakeholders. The framework has not yet been evaluated, as our project is still ongoing, but we intend to evaluate, reflect, and adjust the framework as a final step of our project. We hope that the framework will empower people to make informed decisions about possible responses to pandemics and other health crises. In particular, we believe that the framework can serve as a heuristic design tool for promoting health and well-being and contributing to moving the world toward a sustainable and resilient future.

Acknowledgments

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Exploring Innovation Management System to Understand and Secure Preconditions for Design Thinking

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ABSTRACT

This study explores the critical components of systemic innovation capabilities within nine municipalities, confronting the global goals, through a multi-faceted lens of design thinking (DT) and reasoning approaches. It investigates how an integrated innovation management system (IMS) that spans across organizational levels, embedding inductive, deductive, and abductive reasoning can increase the agility and creativity needed for new solutions to complex challenges. Through qualitative analysis of interviews, workshops, seminars, and strategic documents, the study reveals a dichotomy between the strategic intentions for innovation and the practical maturity of innovation management (IM), specifically the findings suggest that there is a willingness to work with innovation but a lack of a corresponding reasoning approach. It highlights the challenges in aligning strategic innovation objectives with operational frameworks, managing unknown uncertainty, and building bridges between diverse knowledge areas. The findings emphasize the role of politicians and senior management in championing innovation, by recognizing different approaches to uncertainty, showing courage and prioritizing time for exploration. This contributes to public sector innovation by exploring the systemic innovation capabilities essential for public organizations to navigate and lead in an era of rapid change and complex societal demands using DT. The research provides actionable insights for civil servants to craft preconditions for innovation, supporting transformative governance and community engagement.

Introduction

There are many barriers to addressing global goals and solving societal challenges in public sector when complexity is increasing (McDonald III et al., 2022). Among different strategies innovation through DT has become increasingly popular in the public sector in Sweden (Lidman et al., 2022). Over the years the Swedish Association of Local Authorities and Regions has educated hundreds of public sector employees in their “innovation guide”, that is built upon DT principles (Frisk & Bannister, 2022). This approach is seen as a potent tool for navigating and fostering innovation within complex challenges (Pfotenhauer et al., 2019). Despite the push to enhance innovation capabilities by educating staff in design thinking methodologies, it has become apparent that a disconnection exists between the design professionals in the municipalities and

those at the helm—politicians and senior management—who set the stage for a municipality's innovation capacity (Wikström & Heath, 2023).

Dorst (2019) points toward two central issues that confront design professionals in dealing with complex networked situations. Firstly, the difficulty of interpreting the problem situation, and secondly what relationship will be of importance when shaping the appropriate way forward. Regardless of the strategy for innovation support, several challenges in supporting innovation in the public sector have been found, highlighting:

“a lack of direction on what to innovate and implementation phases not being part of the innovation support.” (Lidman et al., 2022 p.40)

Other challenges relate to managers being involved too late in the innovation processes as well as difficulties achieving a commitment to work with innovation within the entire municipal organization.

One aspect of building IM capability from a systems perspective is to understand what innovation work means in an organization. Karlsson and Magnusson (2019) point out that organizations are prone to underestimate what it takes to make their innovation efforts successful. One reason for this is the practice guidance often focuses on methods and tools instead of taking a more holistic approach to building innovation capability (O'Connor, 2012). Dorst (2019) highlights resilience and adaptability as key, and in this paper, we build further on this highlighting a systematic way of managing innovation so that employees dealing with complex problems, societal challenges and global goals using DT get the support they need. Addressing resilience and adaptability calls for a systematic innovation management approach, recognizing the broader implications of innovation work within organizations.

However, while emphasizing resilience and adaptability as crucial for equipping employees to tackle complex societal challenges effectively using DT (Dorst, 2019; O'Connor, 2012), there is a necessity to build a holistic view of robust innovation capabilities, in line with Karlsson & Magnusson (2019). IMS plays a crucial role in helping organizations effectively plan, implement, and evaluate their innovation activities. By taking a systems approach to IM, organizations can ensure that different activities and support mechanisms are interconnected and interact effectively. This holistic view recognizes the systemic nature of innovation capabilities within an organization, focusing on both removing barriers and putting enablers in place. The systems approach guides organizations in assessing and evaluating their innovation performance, making adjustments to address critical innovation capability gaps. This perspective not only complements but also potentially integrates with quality management standards, suggesting that the foundational structure of quality (ISO, 2015) and IM (ISO, 2019) standards can coexist and mutually enhance organizational practices.

Therefore, our research aims to explore the critical components of systemic innovation capabilities in public organizations using DT. The study explores nine different public organizations dealing with societal challenges and global goals.

Conditions and need for innovation in the public sector

The recognition of IM as a strategic approach to harness value from intricate problems has notably enhanced in the last decade even though the fundament can be traced back to Van de Ven (1986). Contemporary studies emphasize the critical role of cultivating innovation capabilities within organizations as a fundamental driver for producing groundbreaking results (Agwunobi and Osborne, 2016). Concurrently, the public sector is encountering an escalating necessity to evolve its operational models. This entails a pivotal transition from New Public Management towards a model rooted in trust, encouraging managers and staff not merely to fulfill their administrative duties but to actively contribute to public value, benefiting citizens and society at large (Torfing and Bentzen, 2020). Moreover, the concept of co-creation has emerged as a crucial element in crafting solutions for these multifaceted issues, necessitating engagement from diverse stakeholders, including citizens and civil society organizations. This complexity amplifies the challenge of aligning public expectations with constrained resources, proposing a novel role for citizens as co-creators in the innovation process (Agger and Lund, 2017). Hence, public sector organizations are tasked with navigating the contradiction between operational efficiency and innovative disruption, alongside reconciling the diverse perspectives, requirements, and frameworks of various stakeholders. Within the public sector, a predominant emphasis on quality management often restricts exploratory initiatives, attributed to an organizational culture and systems geared towards quality assurance, which inadvertently limits opportunities for innovation. As such, integrating innovation cultures and practices with traditional quality management models is essential for augmenting the public sector's innovation potential (Palm et al., 2014).

This discussion is enriched by acknowledging the hurdles in addressing global goals and societal challenges within the public sector, especially as these challenges become more complex (McDonald III et al., 2022). The public sector in Sweden, for instance, has increasingly adopted design thinking as a strategy for fostering innovation (Lidman et al., 2022). Despite these efforts, a notable disconnect, and research gap, persists between design professionals and the policymakers and top management responsible for setting the stage for innovation within municipalities (Wikström & Heath, 2023). Highlighting the difficulty in defining the problem space and identifying critical relationships for charting the path forward in complex networked situations (Dorst, 2019).

Design thinking and reasoning activities

Design thinking, a concept that transcends the mere creation of artifacts to embody a holistic approach to innovation, has evolved significantly from its roots in the mid-20th century. Originating from the scholarly efforts of researchers like Simon (1969, 1996), Lawson (1980, 2006), Cross (1982), Rowe (1987), and Schön (1991), design thinking has expanded into a discipline that integrates creativity, strategy, and user-centeredness with problem-solving and IM. At its core, design thinking leverages a deep understanding of situations involving users' needs and experiences, coupled with a

hands-on, iterative approach to creating solutions (Lawson, 1980, 2006). This methodology emphasizes rapid prototyping, continuous testing, and refinement, fostering a solution-focused mode of problem-solving. It's an approach that advocates 'thinking with hands' and values the process of making as much as the outcome, encouraging designers to engage with situations using materials, sketches, and prototypes to explore and realize innovative solutions.

This creative process is not confined to traditionally trained designers, it has permeated various disciplines, including management (Boland & Collopy, 2004). Anyone can learn from and apply designerly ways of thinking to enhance innovation and strategy within their organizations (Buijs, 2012). This democratization of design thinking has led to its adoption by leading firms like IDEO and has been integrated into management education, underlining its relevance beyond the design studio. IM, particularly in the context of tackling complex and indeterminate problems, has greatly benefited from using DT (Buchanan, 1992, Auernhammer & Roth, 2021). The DT approach offers a structured yet flexible framework that enables navigating the uncertainty and ambiguity inherent in the innovation process. By fostering a culture of experimentation, empathy, and open-mindedness, design thinking encourages and enables organizations in to diverge and explore a broad spectrum of ideas before converging on the most viable solutions.

Central to this process is the known and unknown uncertainty, where the latter can be maneuvered by abductive reasoning, allowing for framing and reframing challenges and opportunities creatively (Roozenburg, 1993), this form of reasoning supports the generation of novel ideas. It facilitates a deeper engagement with the problem space, enabling designers and innovation managers to uncover insights that may lead to breakthrough solutions. Abductive reasoning, or abductive-2, a concept that Dorst (2011) emphasizes for its critical role in navigating complex situations, the unknown uncertainty, is different from deductive and inductive reasoning, which navigates known uncertainty. Abductive reasoning allows designers to make leaps in logic to form hypotheses when faced with incomplete information. This type of reasoning is essential for interpreting complex scenarios and identifying key relationships that guide future directions. It enables envisioning potential solutions without having a complete set of data, thus fostering innovation through creativity by managing the unknown uncertainty.

In addition, abductive reasoning in DT is particularly impactful as it encourages the exploration of multiple perspectives and solutions. By hypothesizing what might be, rather than what is or what necessarily follows from given premises, design thinkers can break free from conventional problem-solving patterns. This openness to exploration and the capacity to envision a range of possibilities is what sets DT apart, making it a powerful approach for addressing global goals in today's society.

In the context of the Swedish public sector, the application of abductive reasoning through DT has the potential to transform how social welfare is conceptualized, developed, and delivered. By prioritizing user needs and experiences, public sector

organizations can create more effective, efficient, and user-friendly solutions. This approach not only leads to innovation but also enhances the relationship between the global goals, the public sector, and the citizens it serves, fostering a culture of trust and collaboration. Moreover, the practice of DT in IM transcends traditional boundaries, incorporating a diverse range of perspectives and stakeholders. The emphasis on human-centered design aligns with the principles of abductive reasoning, prioritizing empathy and user needs in the innovation process, and fosters a more inclusive and participatory innovation ecosystem.

We claim that combining a systemic view of IM with abductive reasoning as found in DT creates a potent framework to tackle the complexities inherent in contemporary innovation challenges. This synergy allows organizations to embrace uncertainties, both known and unknown, and exploit the innovative capacity of DT. By doing so, public organizations can adeptly maneuver the multifaceted river of innovation, anticipating changes with dexterity and insight. Such a holistic integration can drive the creation of transformative solutions and foster a learning-oriented, adaptable culture, both of which are decisive for innovation processes.

Method

The methodology of this study is anchored in co-productive research principles, as delineated by Lindhult and Axelsson (2021), and entails a collaborative framework between the researchers and nine organizations. The principles followed are; equal and empowering relationships, collaboration and participation, interactive and active designs, method mixing and integration, and finally reflective practice and ongoing inquiry. This multi-year study involved these principles where the participating organizations recognized the complexity of their operational contexts, separately or together they sought innovative structures for enhancing innovation capabilities. The co-production of this research was not merely transactional but was rooted in a mutual exploration of dealing with complex challenges where the researchers acted as facilitators and experts within the field of DT and IM.

Table 1, sources and quantity of data collection.

Data source	M1	M2	M3	M4	M5	M6	M7	M8	M9
Interviews	9	11	8	16	11	7	13	*	*
Workshops	10	12	12	8	7	8	5	5*	5*
Meetings	4	6	6	5	4	5	3	4	4
Archival documents	4	4	3	5	4	5	4	5	6

*= interviews have not been performed, extensive complementary data was collected.

The participating organizations were selected through their exploration and curiosity of building capability for dealing with complex challenges, all nine organizations have, in

different ways, contacted us as researchers in their strive for knowledge. Thus, the empirical foundation of this research has been triangulated through interactive modalities with the participating organizations (M1-M9) based on the data sources described below and quantified in Table 1.

Interviews were performed semi-structured with top politicians and managers in each municipality (see example of questions in Figure 1), aiming to capture a broad spectrum of insights into the organizations' innovation maturity. They were recorded and transcribed to ensure accuracy in data interpretation. The *workshops* were designed based on results from the interviews and conducted between the organizations in different settings to foster knowledge exchange across different domains. The workshops emphasized curiosity about organizational differences and the sharing of experiential knowledge. Managerial *meetings* have been conducted with each municipality's management team separately. These interactions focused on strategizing and envisioning future directions and maneuvering innovation in organizations. We have also gathered *archival documents* such as policy documents, action plans, political programs, and other strategic documents describing ways forward for each municipality.

4. Strategic direction
 - a. Is there a clear vision and concrete goals for your innovation work?
 - b. How are these anchored in the organization?
 - c. Are resources also clearly linked to work towards these goals and the vision?
 5. Systems approach
 - a. How do you follow up on your goals in your innovation work?
 - b. How do you work to make it even better?

Figure 1. Examples of questions in the semi-structured interviews

Apart from interview transcriptions, all other forms of interaction—workshops, and meetings—were documented through field notes, collection of workshop materials, and participant feedback.

Data and analysis

The analysis performed is based on Gioia et al. (2013) and performed interactively as described below. The comprehensive data collection was crucial for capturing the multifaceted nature of organizational interactions and perspectives. Following data collection interaction, preliminary discussions (when applicable) among the researchers were conducted to identify emerging themes and insights. This immediate reflection allowed for the iterative refinement of subsequent data collection efforts. The data sources were analyzed separately in “First order analysis” and thematically analyzed in “Second-order analysis” and “Aggregated dimensions”

Structured Data Analysis

First-order analysis: Initiated with analysis of the transcribed interviews, field notes, and collected materials, identifying key concepts that were given names as expressed by the participants themselves or described in strategic documents, aligning with Gioia et al.'s (2013) recommendation for first-order coding.

Second-order analysis: Proceeded to abstract these first-order concepts from each source into broader themes, reflecting the researchers' interpretation of the data. This step involved a rigorous process of comparing and contrasting emergent themes, seeking patterns and relationships that signify underlying strategies of IM.

Aggregate dimensions: The final step involved synthesizing the second-order themes into overarching dimensions, encapsulating the core strategies employed by municipalities to tackle societal challenges through design thinking and how they manage the conditions necessary for the processes needed

This methodological approach, grounded in co-productive research and enhanced by Gioia et al.'s structured data analysis technique, provided a robust foundation for exploring the role of IMS for design-driven innovation in municipalities. By systematically categorizing and analyzing the data, this study contributes to a nuanced understanding of critical components and the role of IMS and DT in addressing global goals.

Analysis, results, and discussion

The analysis, results, and discussion section is built up around the different types of data collected and presented in a descriptive format together with the discussion.

First-order analysis

Semi-structured interviews and conversations

In the analysis of the interviews and conversations, the emphasis is placed on the strategic necessity for public organizations to enhance their innovation capabilities. This analysis highlights three key areas: "Need for strategy," "Strengthening capacity," and "Developing culture and communication". These areas derive from 20 needs formulated in the "Second-order analysis" as shown in Table 2.

Table 2, the 20 formulated needs mapped to the three key areas.

Need for strategy	Strengthening capacity	Developing culture and communication
Need for a structured approach to innovation	Need for leadership in innovation	Need for strategic communication at all levels
Need for strategic insight utilization	Need for cohesive organizational culture	Need for operational clarity and employee empowerment
Need for clear and measurable goals	Need for structured management of innovation initiatives	Need for supportive infrastructure for innovation

Need for accountability in goal achievement	Need for effective uncertainty and resource planning	Need for leadership in fostering an innovation culture
Need for ongoing evaluation and enhancement	Need for organizational learning and knowledge sharing	Need for an open and trustful organizational environment
Need for a comprehensive innovation strategy	Need for clarity in innovation intentions	Need for proactive problem-solving and navigation
Need for practical implementation of strategy	Need for value realization in innovation	

Need for strategy: The interviews outline the importance of having developed systems and structures for innovation within an organization, as highlighted below:

"Sometimes I feel that we are actually running very fast in many different directions. It can create a problem, that the tip becomes too blunt." Municipal director in M6.

Emphasizing that to create value, there must be a clear strategic direction with an overarching system and structure in place. This allows for the understanding and utilization of insights, enhancing the organization's strategic direction and innovation capacity. The analysis also stresses the significance of clear, long-term, and agreed-upon strategic goal formulations for actionable and measurable outcomes.

Strengthening capacity: The analysis highlights the critical role of senior management in fostering innovation.

"...there is a permission. But I don't really think that we take it fully, as we should be able to." Municipal director in M1.

Illustrating that for innovation to occur, knowledge and an understanding of what's required are crucial, the preconditions and adapting to the principles of IM.

"But we are still a fairly traditional organization in a conservative context. That being said...yes, this is going to be a challenge, absolutely. And you would think that you could organize things differently, but I'm not so sure that... I rather believe in using the governance tool much more. So that the answer is probably not in how we are organized, the answer is in something else." Municipal director in M1.

This "something else" could be seen as a need for portfolio management to organize innovation initiatives, emphasizing the importance of prioritization and uncertainty management. Additionally, we identified a need to clarify intentions and expectations within the innovation process to realize value.

Developing culture and communication: The analysis stresses the need for strategic conversations and processes to cultivate a strong innovation climate where employees feel part of the innovation work and can grow through it.

"...are afraid civil servants who do not dare to speak out...don't want to face politicians. And it is directly harmful if we are going to talk about innovation." Politician in M4.

This points to a need to establish functions to provide the necessary support for innovation and renewal, highlighting the importance of a culture of openness for addressing challenges and navigating situations effectively.

Throughout analyzing the data, the recurring theme is the systematic approach of IM, from strategic alignment and capability building to fostering a conducive organizational culture and communication. The analysis underscores the balance between exploitation and exploration, and the integration of various stakeholders' perspectives, needs, and organizational structures to bolster innovation capabilities within these organizations. The analysis calls for a blend of strategic, tactical, and people-centric approaches to embed innovation into the organization, addressing the complexities of the systemic barriers for the effective realization of innovative outcomes.

Workshops

The analysis from the workshops (see Fig 2. Images from workshops) provides a comprehensive examination of the intricacies involved in managing innovation within municipalities. It articulates both the challenges and ways to strengthen the organization encountered by participants in embedding innovation practices within their organizations. The challenges primarily revolve around the difficulties in measuring the effectiveness of innovation systems, establishing a clear strategic direction for innovation that aligns with organizational goals, and integrating the strategic direction of innovation with existing operational documents. There's a noted tension between the traditional approaches to goal setting, which tend to be more linear and quantifiable, and the inherently exploratory and uncertain nature of innovation processes. This tension underscores the need for a more nuanced evaluation of the innovation system as a whole, suggesting a strategic approach that accommodates both structured (top-down, quantitative) and unstructured (bottom-up, qualitative) methods of evaluation.

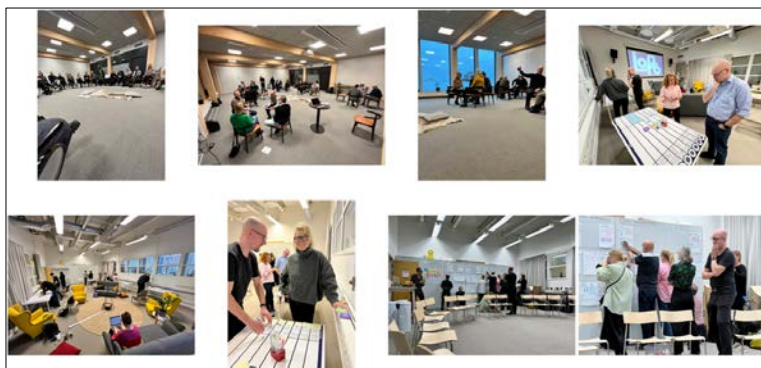


Fig 2. Images from different workshops in different settings.

To strengthen the organizational capability for innovation the pivotal role of senior management in championing innovation is highlighted among the establishment of portfolio management to systematically organize innovation initiatives and the importance of clarifying intentions at the outset of the innovation process. These dimensions point to the critical need for a supportive organizational culture that fosters open communication and strategic conversations across all levels of the organization, where a systems approach to innovation is needed (Karlsson & Magnusson, 2019). This culture is essential for developing a robust innovation climate where employees feel empowered to contribute to innovation efforts and can see the value in their contributions. The insights emphasize the complexity of implementing an effective IMS and the importance of strategic, tactical, and cultural considerations in fostering an environment conducive to innovation.

Meetings

Seminars and meetings have been based on the insights provided in workshops and interviews and specifically integrating knowledge from IM theories, based on that municipalities face significant challenges in creating preconditions for innovation within their organizations. These challenges can be described as deeply rooted in the processual and cultural aspects of municipal operations, particularly in their inclination towards analysis or pace.

Specifically, concrete insights were made in meetings when lifting the article by Beckman & Barry (2007) on innovation as a learning process through embedding design thinking, as described by one politician in a meeting.

"...the reason why we get stuck in the concrete is basically that we don't advise time to explore and we are not brave enough to go into the abstract". Politician in M3.

The insights reveal that municipalities tend to remain within the "concrete" area, which suggests a predilection for tangible, immediate solutions over exploring abstract, potentially more innovative possibilities. This approach, while pragmatic, limits the scope of innovation by prioritizing short-term fixes over long-term systemic changes. Beckman & Barry (2007) emphasize the importance of oscillating between abstract and concrete thinking to foster innovation. This dynamism enables a richer exploration of possibilities, a crucial step that municipalities seem to bypass in haste, thus missing out on solutions that could be revealed with a more patient, exploratory approach.

Moreover, the fear of making wrong decisions that leads municipalities to prolong the analysis phase indefinitely is indicative of a risk-averse culture. This culture stifles innovation by prioritizing safety and predictability over the potential gains of novel solutions. In this Beckman & Barry (2007) argue for embracing a learning process that includes making mistakes and iterative refinement. This approach is essential for innovation, as it allows for the exploration of uncharted rivers with the understanding that not all initiatives will succeed, but all will yield valuable insights.

Archival documents

When analyzing the strategic documents from an innovation perspective the strategic intents regarding innovation across the nine municipalities reveal both shared aspirations and unique approaches. All municipalities emphasize sustainability, digital transformation, and community engagement as foundational elements of their innovation strategies. They recognize the importance of embracing digital development, fostering collaboration (both locally and internationally), and committing to long-term sustainable goals. Each municipality acknowledges an understanding that innovation requires courage to tackle challenges, adaptability in the face of rapid technological advancements, and a focus on sustainable development. Overall, the strategies in these documents highlight a collective orientation towards innovation driven by sustainability, digitalization, and community involvement but diverge in their methods of engaging with the innovation process, fostering a culture where it is okay to make mistakes, and allocating resources for exploration.

Second order analysis

This analysis succinctly captures the dual nature of managing innovation within organizations, reflecting both the systemic obstacles and the inherent insights of adopting a structured approach to IM. The insights extracted from the different data sources, interviews, workshops, and meetings, correlate with general elements of an IMS as displayed in Table 3 where we highlight one central challenge and one insight for the six system elements presented.

Table 3, challenges and insights concerning IMS elements

IMS elements	Challenges (hinders now)	Insights (ways forward)
Evaluation and improvement	Integrating an IMS with existing operational frameworks can be complex, as it requires aligning innovation strategies with traditional processes.	An IMS fosters a structured approach to innovation, enabling organizations to systematically capture and analyze learning from and within innovation activities.
Planning	Establishing measurable and strategic innovation objectives that align with the broader organizational goals can be difficult, often due to the uncertain nature of innovation outcomes.	Effective planning allows for the setting of clear, long-term innovation goals that are understood and agreed upon within the organization, providing a coherent direction for innovation efforts.
Process	Balancing between the need for structured processes and the flexibility required for	A clearly defined innovation process enhances the organization's capability to

	exploratory activities presents a significant challenge.	manage and streamline innovation initiatives, from intent to value.
Support	Ensuring that there is adequate support for innovation, including resources, tools, and methodologies, can be challenging, particularly in aligning these supports with the needs of innovation teams.	Establishing abilities, functions, and roles dedicated to supporting innovation ensures that initiatives have access to the necessary resources and expertise when needed.
Leadership	Engaging senior management and securing their commitment to innovation initiatives can be difficult, especially in organizations where innovation is not yet deeply embedded in the culture.	Strong leadership support for innovation acts as a catalyst, driving the organization's innovation agenda and fostering a culture that values and encourages innovation.
Context	Adapting the innovation strategy to fit the specific contextual challenges and opportunities of the organization, including regulatory, demographical, and technological factors, can be complex.	A well-understood context enables the organization to tailor its innovation efforts to leverage external trends and internal capabilities effectively, maximizing the impact of its activities.

The reasoning approaches

So far in the analysis, when dealing with the global goals, we believe that municipalities need a mix of abductive, deductive, and inductive reasoning. On one hand, when exploring the data sources interviews, meetings, and workshops there seems to be a predominant reasoning based on either induction or deduction, and on the other hand, when exploring the strategic documents they suggest a more forward-looking approach where abductive reasoning is needed. In line with this is the fact that DT, widely spread within these organizations, is based on abductive reasoning, and through this there is a need to understand and use abductive reasoning at all managerial levels when using DT as an approach to innovation. Below we elaborate on this in relation to the results presented.

In the process of managing innovation and global goals within municipalities, it is observed that a blend of abductive, deductive, and inductive reasoning is needed. While exploring the data sources such as interviews, meetings, and workshops they reveal a predominant reliance on induction or deduction, exemplified by:

- The preference for tangible solutions over abstract explorations.
- The prolongation of the analysis phase in decision-making is due to a risk-averse culture.

Conversely, the analysis of strategic documents reveals an inclination towards a forward-looking methodology, signifying the necessity of abductive reasoning, characterized by:

- The tension between the exploratory nature of innovation processes and traditional, linear goal setting.
- A proactive rather than reactive approach to technological advancements and emerging needs.

The necessity aligns with the widespread adoption of DT within these organizations, which fundamentally relies on abductive reasoning. Thus, due to the predominant nature of using induction or deduction, there is a crucial role among senior management in championing innovation, advocating abductive reasoning with the formation of hypothesis in the early phases of innovation processes. This implies that for an organization utilizing DT as an approach to innovation, there must be a comprehensive understanding and application of abductive reasoning across all managerial levels since abductive reasoning is characterized by hypothesis formation based on the best information available. Even though municipalities apply this reasoning in developing new policies or long-term goals in documents talking about what they want to achieve in response to observable patterns, such as demographic changes or sustainability shifts. When setting the stage for preconditions to manage the innovation process, deductive or inductive reasoning is observed as predominant, starting from either a general theory narrowing down to specific instances, acting in reaction, or, acting from a risk-adverse perspective, extrapolating general principles from specific instances.

Our data shows that these three styles of reasoning need to be utilized in conjunction, as evidenced by the necessity of clarifying intentions within the innovation process to realize value. Where the generation of a new hypothesis about the impact of i.e. an upcoming social services legislation using abductive reasoning and then applying the new law through deductive reasoning, and adapting social services based on local usage data with inductive reasoning. Based on this we see that municipalities need to incorporate more of the DT ethos into their IMS by allocating more time to explore abstract possibilities without the immediate pressure for concrete solutions, thus fostering a culture that values creative exploration and learning from failure. By doing so, municipalities can navigate uncertainty in modern governance with innovative solutions that are both effective and forward-thinking.

Aggregated dimension, the critical components

As outlined below, three aggregated dimensions are central to building capacity for innovation in public organizations; learning to manage uncertainty, building courage in decision-making, and understanding that innovation takes time. One way of managing uncertainty in the public sector is to use DT as an approach to innovation. This, because

DT is an approach that is performed iteratively where decision-making is based on new learnings within the innovation process. The use of this approach in the public sector has been growing over the last ten years. However, there might still be issues regarding how effective the approach is. Also, we experience a growing frustration in the participating municipalities in how to increase the pace of value creation in these processes. While the strategies and approaches formulated in strategic documents from the studied organizations are clear in both the need for innovation and the use of a DT approach, the interviews, workshops, and meetings uncover a quite unmaturing ability in IM and a somewhat weak utilization of DT. Strengthen the utilization of DT as a systemic approach to IM helps organizations effectively plan, implement, and evaluate their innovation activities in a systematic and address the critical components below.

Approaches to uncertainty: Some municipalities, like M1 and M5, focus on integrating innovation into their operations and broader society, showing a proactive stance towards managing uncertainty through digital opportunities and sustainable development. In contrast, others like M8, prioritize significant digital transformation, indicating a reactive approach to uncertainty by adapting to emerging needs and technological advancements.

Courage and exploration: Municipalities like M2 and M9 highlight collaborative ventures and employee-driven innovation as mechanisms to foster courage among stakeholders, indicating an emphasis on collective strength and internal expertise to explore new solutions. Meanwhile, M3 and M7 stress community engagement and global alignment as foundations for innovation, suggesting that courage is cultivated through inclusivity and alignment with broader sustainability goals.

Time for exploration: Municipalities allocate time for exploration differently, with some like M5 involving the community extensively in urban development strategies, reflecting a slower, more inclusive process. Others, such as M6 and M4, emphasize the efficiency of innovation processes and goal setting, indicating a more structured approach to exploration within specific timeframes.

This makes us expand the work of Lidman et al. (2022), and suggest that for municipalities to effectively engage in hypothesis testing and explorative endeavors across various domains, both internally and externally, it is imperative for politicians and top management to have a strong grasp of abductive reasoning. Such proficiency is crucial for fostering an environment where diverse competencies can synergize, thereby facilitating resilience in the application of DT as advocated by Dorst (2019). Therefore, both politicians and senior management in the public sector play pivotal roles in interpreting the problem situation and opening up for collaboration for ways forward.

Conclusion

This research emphasizes the systemic innovation capabilities that public organizations must cultivate to effectively address global goals. It elucidates the need for a comprehensive approach that spans various levels of the organization and integrates

multiple reasoning styles to foster innovation. The empirical findings underscore three interlinked innovation imperatives: approaches to uncertainty, courage, and time for exploration. The necessity of a well-articulated strategic direction (Lidman et al., 2021) is brought to the fore, underscoring the importance of robust systems and structures to leverage innovation insights strategically. The study also points to the pivotal role of politicians and senior management in nurturing an innovation-conducive environment and the establishment of clear expectations and flexible innovation practices.

Drawing on the interplay between inductive, deductive, and abductive reasoning, the study delineates the capacity required to create enabling preconditions for employees to innovate through DT. The public sector needs to develop the capacity and understanding of managing the unknown uncertainty throughout the entire organization to make innovation happen. We elaborate on the different aspects of inductive, deductive, and abductive reasoning (Dorst, 2011) to understand the capability needed on different levels in a public organization to create the maneuvering spaces (Van de Ven, 1986) needed for employees to innovate through DT. Highlighting the need for courage in abductive reasoning for exploring what might be, among politicians and managers at all levels of the organization, concerning their focus on exploiting what is already known. Lastly, we focus on time where concerns of pace in innovation are compared to the need of time to understand the problem situation and bridge different knowledge areas within and outside a municipality to uncover insights that drive future paths.

We highlight two limitations of this study; the limited group of municipalities (nine) involved in the study brings questions regarding its generalizability, and the fact that these themselves searched for ways forward indicates a mature understanding of the need for new ways of working that might have impact of the findings. Therefore more municipalities must be studied in different ways to further validate these results. Also, it would be of interest to explore other types of public organizations to understand if they recognize the same challenges and critical components.

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Understanding the Needs of Nonhuman Stakeholders in Design Process: An Overview of and Reflection on Methods

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ABSTRACT

Design practice traditionally focused on human concerns, either overseeing the various effects of climate issues on nonhuman stakeholders or considering them as resources to address these problems. The climate crisis's urgency demands a design shift towards sustainability and inclusivity. This shift was happening through an emerging theme in design, More-Than-Human (MTH), which expands the notion of the user to animals, things, nature, and microbes. Such an expansion creates a requirement for designers to consider nonhuman perspectives during the design process. This paper investigates the methods used in MTH Design studies to explore and synthesize the perspectives of nonhuman users. Reviewing 30 papers, it highlights a predominant focus on animals and things over plants and microbes in MTH studies, along with a scarcity of synthesis methods. It identifies the necessity of tools that represent nonhumans with their relationships within larger ecosystems, and calls for increased attention to plants and microbes, emphasizing their vital role in sustainable environments and urging researchers to develop methods for understanding these species. By highlighting method strengths and weaknesses, it aims to guide designers and design researchers who plan to work with nonhuman users in selecting appropriate methods.

Introduction

Climate change is a serious threat to our planet, and immediate action is needed to transition to a more sustainable future. As we deal with the effects of environmental degradation, such as the continuous rise of carbon dioxide levels and increased frequency of heat waves, droughts, and floods (United Nations, 2023), the significance of implementing sustainable practices becomes evident.

Design could contribute to sustainable futures as a discipline with diverse tools and methods to address wicked problems. Previous studies on sustainable design explored various facets of such a contribution, concentrating on environmental, social, and economic sustainability (Scuri et al., 2022). While earlier sustainable design approaches focused on product-level solutions (e.g. eco-design, green design, biomimicry), in time, this focus has shifted to system-level solutions (e.g. Product Service Systems, Design for

Systems of Innovations and Transitions) (Ceschin & Gaziulusoy, 2016), and more recently, the field embraced the notion of More-than-human (MTH) Design.

MTH Design's approach to sustainability aims to make the well-being of diverse stakeholders, including animals, plants, and ecosystems, central to sustainable design solutions. This approach is based on the notion that humans are not the only species influenced by the negative consequences of environmental problems, and that humans and nonhumans are part of a bigger network (Haraway, 2013; Forlano, 2016), co-existing and entangled (Häggström, 2019; Westerlaken & Gualeni, 2016). For instance, extreme heat and droughts have a direct or indirect negative impact on animal health and well-being (Lacetera, 2019). Terrestrial biodiversity is also being lost because of altered land use, such as the expansion of farmlands (Malhi et al., 2020). Thus, approaching these issues from a human-centered perspective imposes limitations. To build more "inclusive" sustainable futures (Markard et al., 2012), the perspectives and needs of nonhuman stakeholders should be considered alongside those of humans, and relationships between humans and nonhumans should be considered in design (Forlano, 2016; J. Liu et al., 2018; Tomitsch et al., 2021).

The introduction of MTH and Post-humanistic values to design literature (Cox et al., 2020; Behzad et al., 2022; Oogjes & Wakkary, 2022) expanded the definition of "user" from its initial conception, which represents humans as the primary users of products, services, and systems, towards a concept including both humans and nonhumans as users (Coskun et al., 2022; Oogjes & Wakkary, 2022). These nonhumans include animals (Smith et al., 2017; Phillips & Kau, 2019; Biggs et al., 2021; Heitlinger et al., 2021; Wolff et al., 2021), things¹ (Chang et al., 2017; Giaccardi et al., 2020; Reddy, Kocaballi, et al., 2021), ecological systems (Pettersen et al., 2018; S.-Y. (Cyn) Liu et al., 2018; Biggs & Desjardins, 2020; Pollastri et al., 2021a; Wolff et al., 2021) and microorganisms (Chen et al., 2021).

Although considering nonhuman perspectives is crucial for a sustainable future, including their perspectives in the design process and shaping the design outcomes in alignment with their needs is challenging for design researchers and practitioners. This is due to humans' tendency to see nonhumans through human practices (Harrison & Hall, 2010), and undeniable biological differences between them, such as being able to speak (Hastrup, 2015). Hence, the effectiveness of existing human-centered design thinking methods (elicitation techniques like interviews, surveys, focus groups, synthesis techniques like persona, empathy maps, and scenarios) in exploring the perspectives of nonhuman stakeholders is questionable.

Previously, design researchers employed various methods to mitigate this challenge. For instance, they used noticing (Oogjes & Wakkary, 2022) and contact zone (Prost et al., 2021) to facilitate encounters with nonhumans and reflections on these encounters, or animal persona (Hirskyj-Douglas et al., 2017) to represent animals in the design process. While numerous techniques have been proposed to understand nonhuman perspectives

¹ We use the concepts of "thing" and "object" as synonyms.

in the design thinking process, the dominance of human-centered methods persists, and the diversity of methods focused on MTH perspectives remains limited. Additionally, the lack of an overview of these methods makes it difficult to identify their benefits and drawbacks, thus preventing the design research community from selecting the appropriate methods.

In this paper, we aim to address this gap by reviewing 30 papers that utilize an MTH Design approach, looking closely into the methods used in the early stages of the design process to elicit and synthesize the requirements of nonhuman users. Our review showed that methods to synthesize the nonhuman perspectives are fewer than methods to explore these perspectives and that studies focusing on plants and microbes represent a minority compared to studies focusing on animals and things. Our findings also revealed a transition from methods addressing a single nonhuman to those addressing multiple nonhumans. Besides these, we contribute to the literature by categorizing the methods based on their objectives (i.e. reflection, imagining, and data gathering) and by presenting their strengths and weaknesses. Thus, this paper could be a valuable source for design researchers and practitioners interested in MTH Design in selecting the appropriate method for exploring and synthesizing nonhuman users' needs and perspectives.

Related Work

More-Than-Human Design and Sustainability

MTH Design utilizes diverse theories and practices connected to different fields, including posthuman (Forlano, 2017), new materialism (Braidotti, 2013), feminism (Weheliye, 2014), actor-network (Latour, 1996), and object-oriented ontology (Harman, 2017). It argues that humans are not the only users of design outcomes (Coulton & Lindley, 2019), and thus designers should account for nonhuman stakeholders (French et al., 2020; Hirschy-Douglas et al., 2017), promote ecological sustainability and interspecies well-being (Kirk et al., 2019; Porter, 2019), and design for co-habitation (Tironi et al., 2023) rather than only focusing on humans as users.

As addressing sustainability solely through a human-focused lens, without acknowledging their interdependence with nonhumans, is insufficient for achieving a sustainable future (Rupprecht et al., 2020), MTH perspectives have been explored and found resonance in sustainable design (Coskun et al., 2022). Examples include exploring how to include MTH perspectives in urban design (Clarke et al., 2018, 2019; Metzger & Lindblad, 2020), MTH spatial planning practices (Metzger, 2014, 2019; Metzger & Lindblad, 2020), MTH media architecture with a focus on self-owning autonomous forests (Sheikh et al., 2021), translating plants' experiences into the human language (Steiner et al., 2017), using design to arouse curiosity about nature (Portocarrero et al., 2015), and foster empathy towards microbes (Chen et al., 2021). Commercial examples

include products such as PlantWave (*PlantWave*, 2020) and artworks such as Phonopholium to foster interspecies interactions (*Scencosme – Phonopholium*, 2018).

Design thinking is a user-centered process that prioritizes empathizing with users of a product, service, or system (Liedtka Jeanne & Ogilvie Tim, 2011; Wolniak, 2017). While the involvement of users should be considered for each stage, exploring and synthesizing user needs are critical for understanding the nature of a design challenge, uncovering hidden needs and opportunities, and defining the right problem. Looking at the studies focusing on exploring and synthesizing MTH perspectives, it seems that designers and researchers utilize either adapted methods or develop new ones. The former category includes, for instance, animal persona, which is adapted from persona to represent animal stakeholders, and noticing, which is based on autoethnography to foster reflection by engaging with nonhumans in the field. The latter category includes Animal Diplomacy Bureau's Bird Games which let participants experience the world from a bird's perspective, Umwelt-Sketch which aims to visualize how various species perceive and interact with their environment, and Breathing-With which fosters awareness of interconnected relationships between humans and nonhumans through breathing.

Understanding these methods and their use in the design process is crucial for incorporating nonhuman perspectives effectively. This ensures that the resulting ideas, artifacts, or systems from the design process are adequately tailored to meet the needs of nonhumans. Furthermore, examining the use of these methods closely is essential for recognizing their advantages and disadvantages and identifying methodological gaps in the literature. Despite the multitude of techniques used to explore and synthesize nonhuman perspectives in the design process, the literature lacks a study analyzing and providing an overview of these techniques. In this paper, we address this gap through an analysis of 30 papers in the MTH Design field.

Methodology

To find the relevant papers for the review, we used Web of Science as a general-purpose database, the Design Research Society Digital Library, and ACM Digital Library as domain-specific libraries. We searched these venues using the Anywhere function for the following conditions:

1. "More-Than-Human" + Perspective
2. "More-Than-Human" + Understanding
3. "More-Than-Human" + Empathy

Then, we searched again with the "More-Than-Human" condition to identify any missing papers from the previous search. This yielded a total of 2008 papers.

After this collection, we excluded the overlapping papers and filtered the remaining papers according to the following criteria:

1. At least one method used/described in the study should be used for the exploration or synthesis of nonhuman needs.

2. The methods should be used in a design study.
3. The paper should be in English.

Furthermore, we filtered Extended Abstracts and Demonstration papers. This resulted in the selection of 30 papers. We performed our analysis with this set of papers, by asking the following questions:

1. Which nonhuman users were included in the study?
2. How were these users involved? Which data collection method(s) were used?
3. What was the purpose of the methods in the study?

As a final step, we created a sub-group out of the papers in which the authors reflected on the methods they used/described. This sub-group included 17 papers, which we analyzed according to the advantages and disadvantages of the methods (based on the reflections of the authors of these papers).

It should be noted that our aim was not to conduct a systematic review but rather to cohesively present experiences and lessons learned from researchers working with nonhumans in the field. Plus, as our focus is on sustainability, we initially planned to include papers focusing on living entities (animals, plants, microbes, inanimate natural), excluding papers focusing on things. However, thinking that these methods could be adapted for living entities in the future and that there might be important lessons for their adaption we decided to include them in our analysis.

Results

In this section, we first present a broader picture of methods used in the early stages of the design process in the MTH field. Then, we dive into the specifics of these methods, including the contexts in which they are applied, as well as their benefits, challenges, and author recommendations, according to the authors' reflections.

Overview of the MTH Design Research Methods

Figure 1 presents methods used in the exploration and synthesis stages according to targeted nonhumans (e.g. animals, plants) and activities designers engaged in (e.g. reflection, data gathering, imagining).

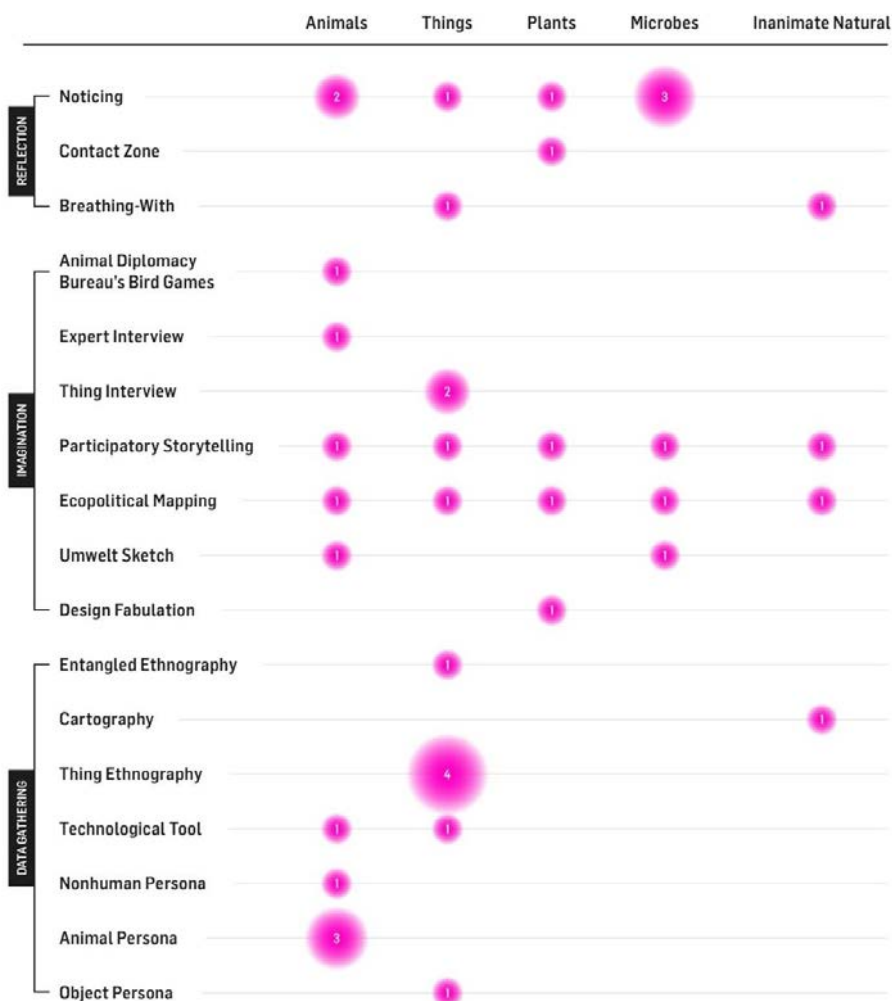


Figure 1: Mapping of methods used in MTH literature for exploration and synthesis.

As seen in Fig. 1, when we examine the exploration and synthesis methods used in the literature, we currently observe that these methods are predominantly used for animals and things. For instance, the *Animal Diplomacy Bureau's bird games* (Phillips & Kau, 2019), and *expert interview* (French et al., 2020) have only been used for animals so far. *Thing interview* (Chang et al., 2017; Reddy, Kocaballi, et al., 2021; Reddy, Nicenboim, et al., 2021), *thing ethnography* (Cila et al., 2015; Giaccardi et al., 2016, 2020; Macruz et al., 2023), and *entangled ethnography* (Murray-Rust Katerina Gorkovenko DMurray-Rust et al., 2019) have been used exclusively for things. Similarly, *technological tools* are used only for things (Cho et al., 2023) and animals (Forkosh, 2021). Additionally, in synthesis methods, *personas* have been used only for animals and things.

Apart from these studies, there are also methods used with plants, microbes, and inanimate natural (air, sea, soil, etc.). These include *contact zone* (Prost et al., 2021) and *design fabulation* (Søndergaard, 2023) with plants, *cartography* (Pollastri et al., 2021) with inanimate natural. *Umwelt-sketch* (Benöhr et al., 2022; De Roo & Ganzevles, 2023) is used with animals and microbes, and *ecopolitical mapping* (Benöhr et al., 2022) is used with animals, plants, inanimate natural, microbiomes, and things.

When we examine these methods according to years, we observe a shift from focusing solely on one nonhuman to exploring or representing multiple nonhumans. For example, *personas* start with *animal persona* (Frawley et al., 2014; Hirskey-Douglas et al., 2017) and *object persona* (Cila & Giaccardi, 2015) and later evolve into *nonhuman persona* (Tomitsch et al., 2021). Likewise, exploration techniques begin with *thing ethnography* (Cila et al., 2015; Giaccardi et al., 2016, 2020), followed by *noticing* focusing on fungi (J. Liu et al., 2018), animals (Biggs et al., 2021; Livio & Devendorf, 2022), and things (Oogjes & Wakkary, 2022) separately. More recently, we have seen *noticing* focusing on plants and microbiomes together (Rosén et al., 2022), *umwelt-sketch* focusing on animals and microbes (De Roo & Ganzevles, 2023), and *participatory storytelling* focusing on animals, plants, inanimate natural, microbiomes, and things (Talgorn & Ullerup, 2023).

Finally, when comparing exploration and synthesis methods (Fig. 1), we see that the number and diversity of synthesis methods are much lower compared to exploration methods. Out of the 17 methods (from 30 papers) examined in our overview, 14 are utilized for exploration, each distinct from the other. On the contrary, only 3 methods are used for synthesis, all of which are adaptations of the persona method.

Insight on Methods

Our analysis revealed that the methods used in MTH Design studies can be categorized according to their intended purposes: data gathering, imagination, and reflection.

Data Gathering

Methods whose purpose is data gathering primarily aim to acquire information about nonhumans through various means (e.g. cameras, experts, proxies). *Thing ethnography* and various *persona* methods including *animal persona*, *object persona*, and *nonhuman persona* are grouped under this purpose.

Thing ethnography (Cila et al., 2015) aims to collect information regarding the utilization, mobility, and interconnections among things & humans, and things & things. This enables the observation and analysis of the behaviors and interactions associated with objects within specific contexts. This method involves collecting visual and aural data about daily objects (e.g. kettles, cups, and fridges) with autographs, and interviewing their users about their daily practices. According to the authors, *Thing ethnography* helps to understand nonhuman perspectives and worlds by revealing their patterns (of use, movement, and time), their role in human practices, and analyzing them in specific socio-cultural settings.

Persona aims to synthesize the information gathered during exploration to make it usable in the design process. In the MTH context, personas facilitate the representation of nonhumans, stakeholders that cannot articulate their perspectives, within the design team. Via *personas*, nonhumans are represented as individuals with their own stories, wants, and needs in the design process in a specific context. *Personas* in the literature include *nonhuman persona* (Tomitsch et al., 2021), *animal persona* (Frawley et al., 2014; Hirskyj-Douglas et al., 2017; Bain & Tomitsch, 2022;), and *object persona* (Cila & Giaccardi, 2015).

To create these *personas*, designers relied on working with experts such as amphibian biologists to get insights about the behaviors of frogs (Bain & Tomitsch, 2022), interviews with proxies such as farmers about characteristics in chickens (Frawley et al., 2014), on-site observation of nonhumans such as collecting frog calls with herpetology experts (Bain & Tomitsch, 2022), reviewing related literature including articles and reports to collect existing information about nonhumans (Tomitsch et al., 2021), and visual data collection about “behavioral patterns, temporal routines, and spatial movements of objects and their users” (Cila & Giaccardi, 2015). *Personas* commonly include demographic information and inner life aspects such as attitudes, motivations, needs, wants, fears, etc. Additionally, in some cases, *personas* represent nonhuman users’ interaction with technology (Hirskyj-Douglas et al., 2017), distribution (Bain & Tomitsch, 2022), and social relations (Cila & Giaccardi, 2015).

According to reflections from all authors using the *persona*, this method helps focus on the end-user requirements of the nonhumans, create a shared understanding of the nonhumans among the design team, assess the product from the perspectives of the nonhumans, and identify different relations between nonhumans and humans. Furthermore, Frawley et al. stated that *persona* helped them challenge dominant practices of the human world where nonhumans are often made invisible, and it created a safe space for the design team to articulate understandings of nonhumans.

The researchers using this method advise to avoid misuse of *persona* as it can lead to solutions detrimental to nonhumans when used to justify the decisions of humans (Tomitsch et al., 2021; Bain & Tomitsch, 2022). They highlight that it is eventually limited to the human mindset and there may be some biases (Frawley et al., 2014; Tomitsch et al., 2021; Bain & Tomitsch, 2022). Furthermore, there is a trade-off between actual representation and generalized representation, and some individual stories may get lost along the way (Hirskyj-Douglas et al., 2017).

Imagining

Methods aimed at fostering imagination primarily focus on integrating data collected about nonhuman stakeholders with imagination to explore nonhuman perspectives. In these methods, data may come from an expert (e.g. expert interview) or a technological tool (e.g. a camera). Under this category, we include six different methods: *narratives*, *design fabulation*, *participatory storytelling*, *thing interview*, *umwelt-sketch*, and *Animal Diplomacy Bureau’s bird games*.

Narratives (Turner & Morrison, 2020), *design fabulation* (Søndergaard, 2023), and *participatory storytelling* (Talgorn & Ullerup, 2023) aim to create stories about nonhumans. In these methods, data is collected through various techniques and sources, including memories from proxies (i.e. dogs' walkers) with questionnaires (on characteristics of the walkers and dogs, walking habits, and "negotiation between the walker and their dogs") (Turner & Morrison, 2020), personal knowledge of the participants (no additional data collection was mentioned) (Talgorn & Ullerup, 2023) and visual data from the microscope (Søndergaard, 2023).

Turner and Morrison put together responses from the dog walkers in a loose form and corroborated with the dog walkers, using the narrative inquiry method. Talgorn and Ullerup designed a story template in which participants answered some questions about the character's motivations, surrounding environment, obstacles the character faces, the outcome of the story, and the changes the character went through. Søndergaard recorded 6 scenes in the microscope, added them together, and used 6 different human voices to "advocate on behalf of the mosses". While the final story is in the form of text in *narratives* and *participatory storytelling* including both humans and nonhumans, the product of *design fabulation* is a video including moss.

According to the reflections from all authors using these methods, they help understand the nonhuman world and their perspectives by seeing "the world from the character's perspective", discovering that they also have stories to tell, learning about their characteristics, and treating them as individuals. In addition, *narratives* help decenter humans in design and discover tensions. *Participatory storytelling* helps increase awareness about the nonhuman world, offers a "non-confrontational" way to engage with the nonhuman world as it uses metaphors, fosters "openness to unknown" and facilitates "overcoming prejudices". Furthermore, *design fabulation* challenges dominant values on nonhumans (such as seeing the microscope merely as a scientific tool) and encourages care relationships.

Søndergaard emphasizes that the *fabulations* should refrain from "oversimplifying and decontextualizing relations with nonhumans". Rather they should be "embedded and embodied, based on specific values, meanings, and priorities". Furthermore, she highlights that simply noticing and perceiving is not enough to understand the nonhuman perspective; imagination is also necessary. However, there should be a balance between them (Søndergaard, 2023; Talgorn & Ullerup, 2023).

Thing interview (Chang et al., 2017) is a "constructive and speculative" approach that aims to create empathy with things from a first-person point of view adapting an originally human-centered method, the interview. In this method, the interviewee role-plays as a nonhuman (scooter) and attempts to respond to the interviewer's questions from the nonhuman's perspective. In doing so, they utilize the information gathered about the nonhuman (i.e. time-lapse photos, daily routines, video perspectives, object portfolios, and event reports). According to researchers who used this technique, it helps understand nonhumans' perspective and world by revealing rich insights into

nonhumans' inner life, their relations with other objects and people, and their subjectivities, and opening a way for empathy between humans and nonhumans. It also allows for an imaginative conversation between humans and nonhumans (who are not able to speak for themselves) through performance. However, they highlight that while the entire process may seem to revolve around the interviewee, both the interviewee's performance and the interviewer's questioning technique are important. The interviewer should ask questions as if speaking to a nonhuman, ensuring an understanding of nonhuman perspectives.

Umwelt-sketch (De Roo & Ganzevles, 2023) aims to discover how different nonhumans perceive and interact with their environment. The method is based on the concept of *Umwelt*, which argues that organisms interact uniquely with the world, guided by their sensory abilities and behaviors. With this method, designers are encouraged to think from the perspective of nonhumans and try to visualize the world from their perspective. According to the authors, this method helps understand nonhuman perspectives and worlds by encouraging sensitivity towards nonhuman actors, exploring different nonhumans on the site, and empathically connecting with them. Furthermore, the method allows participants to decenter human perspectives and oscillate between human and nonhuman perspectives. The authors highlight the importance of gathering information about nonhumans through desk research and experts. They point out that although the method can be successful in understanding nonhuman perspectives, these perspectives may not be adequately represented in the final designs.

Different from other methods, the *Animal Diplomacy Bureau's bird games* (Phillips & Kau, 2019) is a product that aims to immerse participants in the experience of thinking and acting like nonhumans (birds) by taking the role of birds and aiming to gather food points. The game seamlessly integrates elements of the physical with a semi-fictional world. It is constructed upon real life, mirroring the complex dynamics observed among various bird species within a park setting. Moreover, the game's rules are designed to incorporate authentic bird behaviors and interactions. According to the authors, this game helps understand nonhuman perspectives by making participants think about how nonhumans experience parks, encourages discussions about urban life and nature, and enables them to connect with the nonhuman world.

Reflection

Methods designed to foster reflection primarily involve spending time with nonhuman stakeholders and engaging in self-reflection through these experiences. These include *noticing* and *breathing-with*.

Noticing is utilized by three different studies in the literature: with birds (Biggs et al., 2021), with knots (Oogjes & Wakkary, 2022), and with plants and microbes (Rosén et al., 2022). Authors use *noticing* as a reflection method with mainly similar bases. They recommend maintaining openness to new experiences when utilizing this method. Furthermore, they suggest that in addition to experiencing these encounters with an agenda and purpose, the nonhuman entity with whom the experience is shared should

also contribute to shaping these experiences. They note that certain interactions may originate from the initiation of the nonhuman entity.

On the other hand, the scope varies slightly in their research. While Biggs et al. primarily focus on establishing intimacy with the nonhuman world through making, Oogjes and Wakkary emphasize that *noticing* can be achieved through embracing heterogeneity and tension rather than seeking harmony or unity. Rosén et al., on the other hand, argue that what is noticed is not coincidental; rather, it is influenced by factors such as cultural background, values, and beliefs. Additionally, they suggest that *noticing* is not merely about observing the surroundings but understanding systematic patterns and “recognizing oneself as part of these interdependencies”.

Noticing helps in understanding the nonhuman world by bringing attention to the presence of various nonhumans in the environment and revealing previously unnoticed relationships among them (Oogjes & Wakkary, 2022; Rosén et al., 2022). It also helps in understanding the perspectives of nonhuman entities (Rosén et al., 2022) and facilitates a deeper connection with nature (Biggs et al., 2021; Rosén et al., 2022). Biggs et al. add that *noticing* enables this connection through different sensory experiences and helps uncover “new ‘edges’ of the problem”.

All authors using *noticing* emphasize the importance of systematically documenting observations during the noticing process. Rosén et al. highlight the potential benefits of utilizing technology to experience different sensory encounters. Finally, Biggs et al. describe the noticing process as “a psychological labor,” noting the challenges faced in adapting oneself to MTH thinking as a designer and researcher.

Breathing-with is a design method that broadens the concept of the body in design processes to encompass nonhumans (Fritsch et al., 2023). It involves using breathing to foster an expanded bodily awareness, including material, living, and social aspects of the nonhumans. It highlights intimacy, and vulnerability, and navigates the interconnected relationships between humans and nonhumans. The authors used *breathing-with* as an exploration method with inanimate natural (air) and things (wings) in two different ways. First, Breathing Commons involves a series of sessions and workshops exploring breathing as an individual and a collective experience. Breathing Wings, secondly, is grounded in an interactive wearable prototype shaped like wings, to intimately explore the relationship between the human body and its material extension.

Breathing-with facilitates the recognition of the interconnection between humans and nonhumans (such as human-air and human-material (wings)), acknowledging the presence of nonhuman agencies (such as the liveliness of the latex). It helps in understanding the human world by observing various nonhuman stakeholders and exploring ways to coexist with the nonhuman world.

Discussion

This paper presents an analysis of exploration and synthesis methods used in design research papers exploring nonhuman perspectives. This analysis revealed a shortage of synthesis methods versus exploration methods, notably prioritizing animals and things over plants and microbes, and resulted in the identification of the strengths and weaknesses of various methods. We discuss two key points considering these findings.

From Unidimensional User Representations to Entangled Representations

With the introduction of MTH Design, sustainable design studies evolve beyond prioritizing efficiency, perceiving nature merely as a resource and viewing humans as separate from nature (Light et al., 2017; Rupperecht et al., 2020). Discussions surrounding MTH highlight the entanglements and interdependencies among humans, urban environments, and the natural world (Haraway, 2013; Moore, 2017). Therefore, sustainability and envisioning sustainable futures require a holistic perspective that goes beyond individual human or nonhuman perspectives. MTH Sustainable Design advocates for considering these stakeholders as integral parts of a larger interconnected system, fostering a more comprehensive understanding of sustainability, and facilitating the development of inclusive designs for the future. This notion indicates a need for tools that can enable designers and researchers to collect data about nonhumans, humans, and their relations, and represent this data in the design process.

In this study, we found that although there are plenty of exploration methods in MTH Design literature, the variety in synthesis methods is limited and they heavily rely on alterations of persona technique as can be seen in Figure 1. The persona technique is widely used in both human-centered and MTH fields. We recognize the practicality of persona methods in terms of providing a representation platform for nonhuman perspectives as a start. The findings also showed a shift in persona usage from representing one nonhuman to multiple nonhumans already. However, the persona has recently been criticized in the literature for being one-dimensional and unable to represent temporal aspects (Roman, 2019). This limitation is particularly evident in MTH contexts, where the user is defined through entanglements. Hence, we identify a need for tools that focus not only on nonhumans individually (looking for motivations, needs, wants, etc.) but also on their relationships with other stakeholders, how they are defined within these relationships, and the dynamics of these relationships. In this respect, we invite researchers and practitioners working in MTH Design to experiment with methods like stakeholder maps, actor-network diagrams, and eco-system loops.

Need for Understanding Plants and Microbes

This study revealed the scarcity of methods proposed for plants and microbiomes in comparison to animals and things. While 23 studies focus on animals and things, there are only 5 studies focused on plants, 6 on microbes, and 4 on inanimate natural phenomena. One reason for this could be the increasing popularity of IoT devices and

research, coupled with the fact that Animal-Computer Interaction (ACI) has been studied since the 1990s (Mancini, 2011). Additionally, plant-computer interaction (PCI) research and studies with microbes are more recent compared to studies focusing on animals, indicating that these studies represent “the margin of the margin” (Aspling et al., 2016).

Based on the knowledge acquired from our overview and literature, we believe that there is a need for an increase in studies related to plants in the MTH field. Plants maintain the soil structure, microbial communities, and ecosystem functions. They support a greater diversity of habitats for microbial communities and prevent soil disturbance, all of which are very important for biodiversity and sustainable environments (Vezzani et al., 2018). They are vital for life on Earth, yet they face significant extinction threats due to “plant blindness”, a concept referring to the lack of attention toward plants, where their importance in nature and human life is often overlooked (Thomas et al., 2022). Microbes are used as biofertilizers, biopesticides, and bioinsecticides in sustainable agriculture, which are important for promoting soil health and protecting crops. They are also used for fermentation and recycling waste materials are beneficial for ensuring high protein content (Kalsoom et al., 2020). Thus, considering the growing interest in sustainability, future challenges such as food scarcity (United Nations, 2023), plants’ crucial role, and possible design spaces for microbiomes in a sustainable future, we encourage design researchers and practitioners to plan and execute studies that involve plants and microbes, as well as developing new methods that could help understand these species.

Conclusion

In this paper, we examined the methods used in early-stage design processes to integrate nonhuman perspectives, particularly focusing on MTH Design. We reviewed 30 papers to analyze the exploration and synthesis techniques employed, noting a scarcity of synthesis methods compared to exploration methods. Additionally, we categorized the methods based on their objectives and discussed their strengths and weaknesses according to the authors’ reflections, emphasizing the need for more inclusive and comprehensive design methods to address the challenges of sustainability and climate change. While the literature predominantly focuses on animals and things, there’s a pressing need to develop methods that encompass plants and microbes. Furthermore, the MTH Design field needs more synthesis methods focusing on the entanglements between different stakeholders.

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2024, DTRS14, is hosted by Innovation and design at Mälardalen University in collaboration with Copenhagen School of Design and Technology. The symposium is also hosted in conjunction with Mälardalen University Living Lab, an arena for method development that strengthens collaboration between the university, companies and public sector, through the development of methods for co-production. The vision is to contribute, through collaboration, towards a sustainable society from a holistic perspective. The theme of the symposium is: *The role of design in shaping sustainable futures*.

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