The International Journal of Design Management and Professional Practice
ISSN: 2325-162X (Print), ISSN: 2325-1638 (Online)
Volume 18, Issue 1, 2024
https://doi.org/10.18848/2325-162X/CGP/v18i01/31-57

Original Research

Shifting Design Thinking to a Circular Design Perspective: Reframing the Process of Circular Innovation

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Received: 07/15/2023; ***Accepted:*** 11/14/2023; ***Published:*** 01/27/2024

Abstract: Design Thinking (DT) is a valuable design innovation approach, but its application in addressing sustainability challenges within the Circular Economy (CE) paradigm requires a revision from a circular innovation perspective. This article explores the convergence, limitations, and potential of DT and CE, emphasizing the need for a more comprehensive circular and systemic evolution of DT. Frameworks, objectives, and strategies for achieving sustainable design goals through DT are discussed, with an emphasis on integrating DT with the Framework for Strategic Sustainable Development (FSSD) to enhance systemic perspectives and sustainability considerations. The integration of DT with Sustainability-Oriented Innovation (SOI) is also highlighted, emphasizing a systemic thinking approach. Case studies demonstrate the application of DT principles in Circular Design ideation and development, showcasing tools that promote a systemic thinking approach to address sustainability challenges effectively. This article introduces the ongoing CD-TOOLS project, which includes a training program and digital platform supporting Lithuanian entrepreneurs and design professionals in creating circular product-service solutions. The project's contributions to addressing the identified limitations and promoting sustainable design practices are discussed.

Keywords: *Design Thinking, Circular Design, Systemic Design, Circular Design Tools*

Introduction

Design Thinking (DT) is recognized, beyond its limits, as a valuable design innovation approach whose essential characteristics might be helpful when sustainability issues arise. The diffusion of the Circular Economy (CE) paradigm requires a profound revision of DT principles from a circular innovation perspective. This depends on Systemic Design Thinking.

Starting from a statement saying that a whole DT circular evolution has not been completed yet (for example, in terms of a more-than-human perspective, prototype experimental approach, a technoscientific validation process of solutions), in this article, we present DT and CE main characteristics identifying their points of conjunction (and limits). The application of DT in the context of sustainability, specifically within the framework of the

CE and Circular Design, will be discussed, highlighting the need to address the limitations of DT in incorporating sustainability concerns and emphasizing the potential for DT to reinforce CE principles. The subsequent sections will delve into frameworks, objectives, and strategies for achieving sustainable design goals by explicitly using DT as a model and process. We will emphasize integrating DT with the Framework for Strategic Sustainable Development (FSSD), emphasizing the focus on enhancing systemic perspectives and sustainability considerations within the FSSD. Then, we will discuss the integration of DT with Sustainability-Oriented Innovation (SOI) to enhance environmental impact. This section emphasizes the utilization of DT principles to address key challenges in SOI and highlights the need for a Systemic Thinking (ST) approach. Then selected case studies of tools using ST principles and developed for Circular Design ideation and development will be presented.

Finally, we will introduce the approach used in the in-progress CD-TOOLS project, constituted by a training and mentoring program (Circular Design Journey) integrated into a digital platform designed to support Lithuanian entrepreneurs and design professionals in designing circular product-service solutions. How CD-TOOLS has been addressing the issues arising from the previous analysis will be discussed.

Integrating Design Thinking with Circular Economy

DT can be defined as "the application of design methods by multidisciplinary teams to a broad range of innovation challenges" (Seidel and Fixson 2013, 19). It creates a common ground for managers to understand how designers "think" in their workflow, and designers could better align creativity to business and competitive rules (Cross 2001). DT is mainly a human-centered approach toward innovation that tackles the user problem from alternative perspectives, leaving room for an intensive ideation activity where wild ideas are proposed to push the context of the solution toward a newly radical better usage situation. It actively avoids making definitive choices for as long as possible to maximize learning as a deliberate uncertainty reduction strategy (Beckman and Barry 2007 in Guldmann, Bocken, and Brezet 2019). Table 1 summarizes DT themes, practices, and related main references retrieved by Dell'Era et al. (2020).

Table 1: Main Practices of Design Thinking

Theme	*Practices*	*References*
Human-Centered Design	Involving users Empathizing with humans	Brown (2008); Michlewski (2008); Holloway (2009); Ward, Runcie, and Morris (2009); Dell'Era, Magistretti, and Verganti (2018)
Problem Framing	Framing and reframing Abductive reasoning Embracing ambiguity	Boland and Collopy (2004); Dew (2007); Drews (2009); Fraser (2009); Lockwood (2009); Martin (2009); Kolko (2010); Dorst (2011)
Diversity Integrative Thinking	Holistic thinking Interdisciplinary collaboration	Dunne and Martin (2006); Brown (2008); Fraser (2009); Sato (2009); Beverland, Wilner, and Micheli (2015); Luchs, Swan, and Creusen (2016)
Experimentation	Learning by doing Failing often and soon Diverging/converging	Boland and Collopy (2004); Brown (2008); Drews (2009); Fraser (2009); Holloway (2009); Sato et al. (2010)
Visualization	Making ideas and insights visual and tangible Representing abstract concepts	Carr et al. (2010); Drews (2009); Ward, Runcie, and Morris (2009)

Source: Adapted from Dell'Era et al. 2020; Carlgren, Rauth, and Elmquist 2016; Micheli et al. 2019

The most common and known creative process used in DT is the Double Diamond, proposed by the Design Council in 2004, which has already undergone many updates. The Design Council defined it as "The Double Diamond is a visual representation of the design and innovation process. It is a simple way to describe the steps taken in any design and innovation project, irrespective of methods and tools used."[1]

It is mainly divided into four divergent and convergent phases:

- Discover—examining the problem and conducting research to find the demands of the user. It aids in figuring out what the issue is. It is the stage where user research is carried out.

[1] https://www.designcouncil.org.uk/our-resources/the-double-diamond/.

- Define—make sense of the results, recognizing connections between user demands and issues. The designer (business, student, etc.) clarifies the design brief during this step and identifies difficulties.
- Develop—multiple viable solutions are being developed, tested, and improved. During this stage, the designer offers a variety of potential solutions to the clearly defined problem, drawing inspiration from other areas while also working directly with the various stakeholders engaged in the identified problem at various levels.
- Deliver—entails experimenting with many solutions on a small scale, eliminating those that would not work, and enhancing those that will.

The Design Council has already reviewed the Double Diamond model, building a new one called Framework for Innovation. The key other mental models that are helpful in innovation projects have been added to the new model under these design principles: User-Centered Design, Visual Thinking, Co-creation, Agile/Lean Startup, stressing engagement and leadership as critical success factors, as well. The Double Diamond model is a linear process, but in the current global situation, where sustainability is a common goal, applying a circular perspective to design is a must.

A circular approach to innovation (and, therefore, the economy) means avoiding a linear perspective in favor of a circular one. The term circular economy refers to a strategy for improving production and consumption efficiency through the sensible use, reuse, and exchange of resources; businesses constantly work to maximize the value and utilization of their goods, parts, and materials (Guldmann, Bocken, and Brezet 2019).

In addition to designing for the "closed loop," designers have the opportunity and responsibility to lead the paradigm shift. By extending the useful life of products and raising their perceived value, designers can influence business and consumer behavior and consumption. This approach is known as Circular Design Innovation (Andrews 2015). In contrast to sustainable design, Circular Design has a definable end goal to close the loop, while sustainability is a more fluid concept that many stakeholders find challenging to set goals for (Earley 2017). At first proposed by the Ellen MacArthur Foundation (2013) and the Royal Society for the Encouragement of Arts, Manufactures and Commerce (RSA) (n.d.), Circular Design focuses on creating products, services, and systems that support the principles of the CE and aims at developing innovative solutions that extend product life cycles, enable easy repair and maintenance, and facilitate efficient recycling and reuse of materials. It also considers the environmental and social impacts throughout the entire life cycle of a product or system.

However, DT presents several limits in shifting toward a circular economic model. Indeed, DT does not incorporate sustainability concerns unless the user chooses to do so (Santa-Maria, Vermeulen, and Baumgartner 2021; Shapira, Ketchie, and Nehe 2017). This

process takes a partial systems perspective that refers to some stakeholders other than the target audience but needs to be more extensive in scope and long-term thinking (Shapira, Ketchie, and Nehe 2017).

In the following text, we will deepen these shortcomings by trying to theoretically frame DT in/with sustainability, first, CE and Circular Design, then highlight how DT can reinforce CE principles (and vice versa).

Relationship between DT and Environmental Sustainability

This section will provide an overview of how DT has been related to the environmental sustainability issue. Sustainability can be valuable in defining the idea space and selecting possible solutions. Several scholars and researchers have already addressed the relationship between DT and sustainability, looking at and reviewing the Double Diamond process from a CE perspective. Indeed, sustainability, during divergent thinking phases, can drive innovation by opening up the idea space; while in the convergent thinking phases, sustainability aspects can be introduced in the proposed solutions (Shapira, Ketchie, and Nehe 2017; Thompson, Larsson, and Broman 2011).

The overview proposed here will provide a limited understanding of the academic and professional works developed since now. Still, we selected those relationships between DT and sustainability, which gave shape to bodies of knowledge, tools, and methods that are especially useful for training and guiding designers or entrepreneurs in paying attention to their idea of sustainability, a precondition to addressing Circular Design Innovation goals. Indeed, lifelong learning, and therefore education, is a critical factor in ensuring the success of the CE (Suárez-Eiroa et al. 2019; Andrews 2015).

In the following text, we will present first of all a general framework (where-positioning), then specific goals to be achieved (what-objectives), and finally, tools and methods (how-strategies); the peculiarity of our discussion is that DT is explicitly used as a model and a process to develop and achieve them.

Design Thinking + Framework for Strategic Sustainable Development

The FSSD has been developed and applied to assess the sustainability performance of already existing products and industrial plants (Robèrt, Broman, and Basile 2013 referring to Matsushita Electric Industrial 2002; Ny et al. 2008), focusing mainly on the environmental level of sustainability identifying in Planetary Boundaries (PBs) the variables to be addressed and taken into consideration, which were first introduced in 2009 from a pool of scientists collaborating with the Stockholm Resilience Centre (Rockström et al. 2009; Steffen et al. 2015).

The FSSD has been shown to increase "the utility of individual methods, tools, and concepts by highlighting strengths and weaknesses and enabling combinations that create more robust strategic approaches" (Robèrt, Broman, and Basile. 2013, 4).

The FSSD is structured in five simultaneous levels (Robèrt 2000; Ny et al. 2006):

- Systems Level: including both social and ecological systems referring to current sustainability challenges;
- Success Level: including a core purpose statement and values based on the respect of four Sustainability Principles (SPs), which are concentrations of substances extracted and produced, degradation by physical means, and people's capacity to satisfy their (basic) needs;
- Strategic Level: envisioning a desired future and the process to realize it (backcasting).

  > The planner also needs to consider three basic generic strategic guidelines when taking action towards sustainability (Robèrt, 2000): 1. Does this action proceed in the right direction with respect to the SPs? 2. Does this action provide a "stepping stone" (flexible platform) for future improvements? 3. Is this action likely to produce sufficient return on investment? (Shapira, Ketchie, and Nehe 2017, 280)

- Actions Level: including concrete selected actions;
- Tools Level: including "strategic, systems and capacity tools that help reach success within the system's boundaries (Robèrt et al., 2010)" (Shapira, Ketchie, and Nehe 2017, 280).

Shapira, Ketchie, and Nehe (2017), worked to integrate DT into this framework, analyzing and reviewing it through the use of IDEO's Design Thinking for Education (DT4E) toolkit and collecting knowledge and opinion through expert interviews.

The output achieved from the study was the Sustainable Design Thinking Process in which they added to DT traditional model twenty more elements and tools to take into consideration and use for sustainability purposes.

In a more recent review, FSSD (Broman and Robèrt 2017, 20) has been described as comprising:

- A funnel metaphor facilitating an understanding of the sustainability challenge and the self-benefit of competent proactivity.
- A five-level structuring and inter-relational model distinguishing and clarifying the inter-relationships between phenomena of fundamentally different character.
- A principled definition of sustainability useful as boundary conditions for backcasting planning and redesign for sustainability.
- An operational procedure for creative co-creation of strategic transitions towards sustainability.

Moreover, backcasting has been identified as a more appropriate approach for satisfying sustainability requirements in a product-service conception and development (Broman and Robèrt 2017).

What is more interesting for our discussion here is the relationship between FSSD levels and DT because the analysis provided by Shapira, Ketchie, and Nehe (2017) highlights some essential limits that DT presented—at that time—regarding sustainability. In particular, the main takeaways we can highlight here are related to the DT's poor systemic perspective and lack of awareness of potential systemic interactions. Moreover, sustainability should become an additional intersectional DT condition with desirability, viability, and feasibility. For these reasons, we want to finally refer to the Systemic Design Framework launched by the Design Council in 2021. Six systemic design concepts can be used to guide the creation or adaptation of new design approaches and instruments. The guiding concepts are putting the needs of people and the world first; zooming in and out; testing and developing ideas; accepting diversity; cooperating and connecting; and being circular and regenerative (Design Council 2021).

In the following paragraph, we will move on to presenting the SOI approach, which is useful in identifying specific goals to be addressed and achieved.

Design Thinking + Sustainability-Oriented Innovation

We are going on in our discussion, defining sustainability goals using the SOI, especially in relation to DT (Buhl et al. 2019). Environmental concerns have been acknowledged as catalysts for innovation strategies (Noci and Verganti 1999) and sources of strategic change (Aragón-Correa et al. 2008). Eco-innovations are new or improved organizational structures, processes, products, or technology that benefit the environment by minimizing or avoiding negative environmental impacts (Klewitz and Hansen 2014; Beise and Rennings 2005; Rennings 2000).

Buhl and colleagues (2019) identified different DT phases that can favor achieving SOI goals. The authors define SOI "as the intentional creation and realization of new (or improved) products, services, processes or practices which aim at environmental and/or social benefits in addition to economic returns throughout the physical life-cycle" (Buhl et al. 2019, 1249; Hansen and Grosse-Dunker 2013; Adams et al. 2016). Therefore, SOI builds on creative ideas comprising their implementation phase as well; however, the authors are mainly focused on the initial SOI phase, where novel sustainable ideas are proposed and evaluated. Buhl et al. (2019) identify four outcome dimensions based on Hansen, Grosse-Dunker, and Reichwald (2009):

1. Target, which concerns environmental, social, and economic impacts;
2. Life cycle, which stresses the importance of paying attention to the whole lifespan of a product/service (manufacture, use, and end-of-life);

3. Innovation type, the focus is functional rather than technical properties of the product/service;
4. Degree of novelty "ranges from low in e.g. 'incremental' innovation to high in e.g. 'radical' innovation" (Buhl et al. 2019, 1249).

Based on these dimensions, Buhl et al. (2019) determine four key challenges that arise from the SOI process: innovation scope, user needs and behaviors, stakeholder involvement, and assurance of positive sustainability effects. DT can be promising in addressing these SOI challenges, and the authors present specific DT principle(s) to tackle them. We will not provide extensive explanations (we refer to Buhl et al. 2019), but we quickly present them.

The *DT problem framing approach can address the innovation scope* because it explores the problem context before mapping out the scope for innovation (Kolko 2015), using—according to the authors—a systemic perspective. The identification and understanding of *user* needs and behaviors are central in DT, which can help in detecting how these are relevant from a social-ecological point of view that should be translated into design criteria to generate sustainable ideas. However, especially when sensitive topics such as sustainability are concerned, users tend to praise the interviewer; therefore, methods other than interviews (e.g., observations) should be used, or at least the researcher should meticulously refine the interview questions. *Stakeholder involvement* is part of DT's approach, which sees collaboration with a diverse range of people as crucial during the overall design process, not only because of the importance of multidisciplinarity in achieving innovation. This plural involvement is very relevant, especially when SOI is the final goal because all the stakeholders are similarly or differently impacted by and contributing to sustainability issues. At the same time, it can be difficult to involve stakeholders, and their diverse perspectives can be conflicting. Visualization and boundary objects can constitute platforms of sharing and mutual understanding, as we will present in the following section. Achieving positive, sustainable effects are primary condition for SOI development, and DT can help control them through *experimentation and iteration*. In the experimentation phase, different prototyped solutions can be tested with end users and then be further refined and tested again. In the case of SOI, positive sustainability effects "are an intended, but not a certain outcome" (Buhl et al. 2019, 1254); both positive and negative effects can be verified through the users' test, which would have to take into consideration well-defined sustainability checkpoints (authors suggest the use of the "Sustainability Innovation Cube" [SIC] Hansen, Grosse-Dunker, and Reichwald 2009 as an assessment tool).

These scholars provide a reasoning structure using already existing DT tools and methods to pursue SOI. Through this approach, we can identify relevant DT principles to be used, which we can sum up in problem framing, user-centeredness, stakeholder involvement, experimentation, and iteration.

To conclude, the need for the integration of DT with the Systemic Thinking approach and principles is clear. Breuer et al. (2018) define "systemic thinking" as a guiding principle for sustainability-oriented business model development since it involves a focus on life cycle thinking, e.g., from "cradle to cradle" (Braungart, McDonough, and Bollinger 2007), product-service systems and tools like value mapping (Bocken et al. 2013) to reflect sustainability-related outcomes. In addition, Boons et al. (2013) introduce "systemness" as a frequent characteristic of SOI to emphasize that they must engage with a multidimensional and global system of consumption and production to succeed. While we acknowledge the significance of a system perspective for SOI development, we also include non-systemic and rather insular solutions in our considerations as they often represent the first steps toward more systemic SOI for many firms (Adams et al. 2016). Therefore, we regard the system perspective not as a distinct challenge of SOI but rather as an approach for defining an appropriate innovation scope.

In the following section, we will present a few selected case studies of tools developed with the objective of using DT principles and methods to satisfy CE requirements. These tools were mainly dedicated to students, designers, and entrepreneurs who wanted to learn and understand how to ideate and develop a Circular Design idea.

Design Thinking for Circular Economy: Tools and Methods

The use of tools and toolkits for developing Circular Design solutions can be traced back to the development of the CE concept. These aids provide designers and businesses with practical guidance and helpful resources for applying Circular Design principles to their processes. Circular design tools are the resources and platforms that can help you access and use circular design methods and skills. These were developed by various groups, including universities and research centers, international organizations, designers and design agencies, and public institutions, to assist individuals and teams in developing systems and products that are more sustainable, more profitable, and effective. Tools and methods developed according to or in conjunction with DT have been selected; moreover, we considered those that find feedback in scientific literature.

Most of the process models analyzed by da Costa Fernandes et al. (2020) are linear and iterative, although these methods have a sequence of phases. The step-by-step approach indicates that those process models' operations are planned out and carried out methodically, even if this proposed approach might influence the adoption of a linear way of thinking. Although agile and DT methodologies have a significant impact, only a few process models adhere to a prototype process (da Costa Fernandes et al. 2020).

In this contribution, we mention a number of relevant cases that refer to the integration of DT in the overall process. As a premise, we want to mention the United Nations

Environment Program (UNEP) guide called Design for Sustainability,[2] released in 2009. The guide, defined as a step-by-step approach, aims to support designers and industry to improve their knowledge and capabilities on ecodesign. The manual is developed according to three different design approaches: redesign of existing products, radical sustainable product innovation, and new product development. First-time users are further guided by a "how-to" additional section. The guide includes case studies, additional design and management tools, and worksheets. In the guide, DT is not explicitly mentioned, while creative thinking is.

The *Circular Design Guide*

The most well-known and valuable example of the operative integration between DT and CE is represented by the *Circular Design Guide*, developed in 2017 by the Ellen MacArthur Foundation in collaboration with IDEO. It provides a systemic approach to DT adapting methods to the CE goals. These are all available on a web platform where additional learning materials are provided, such as short video lectures and case studies. The guide aims to accelerate the adoption of Circular Design principles and practices across various industries. It supports designers in the integration of sustainability requirements from the earliest stages of the design process, ensuring that circularity is a fundamental aspect of the final solution. The model comprises five main stages: understand, define, make, release, and advance, considering all stakeholders involved from materials extraction to disposal, starting specifically with users and their needs, then moving on to generating ideas, selecting concepts, and constructing prototypes for testing. It offers twenty-four Circular Design techniques that combine DT and CE principles to encourage the creation of products and services for the CE. Additionally, two crucial horizontal approaches to CD are mentioned: service flip and biomimicry (Petronis and Valušytė 2021).

As stated in the platform, designers and entrepreneurs need to become accustomed to the idea of zooming in and out while designing for the CE, focusing on the product that has been created while also being aware of the context position in the larger system and the impacts generated.

In 2019, UNEP released the Circularity Platform, which explains the circularity concept, its application, and how it supports the promotion of sustainable production and consumption patterns. Additionally, it provides a variety of resources and includes case studies showing how different stakeholders have effectively used circular techniques. This platform is not based on DT, but we found it interesting compared with the *Circular Design Guide* for its approach. Indeed, the UNEP's Circularity Platform differs from the *Circular Design Guide* because it attempts to speak directly of the relationships between the actors and their actions in the

[2] In partnership with Delft University of Technology, and international D4S experts from the Netherlands, Sweden, Italy, France, Germany, Japan, and Australia, with support from UNIDO, the Swedish EPA, and in Went, Germany.

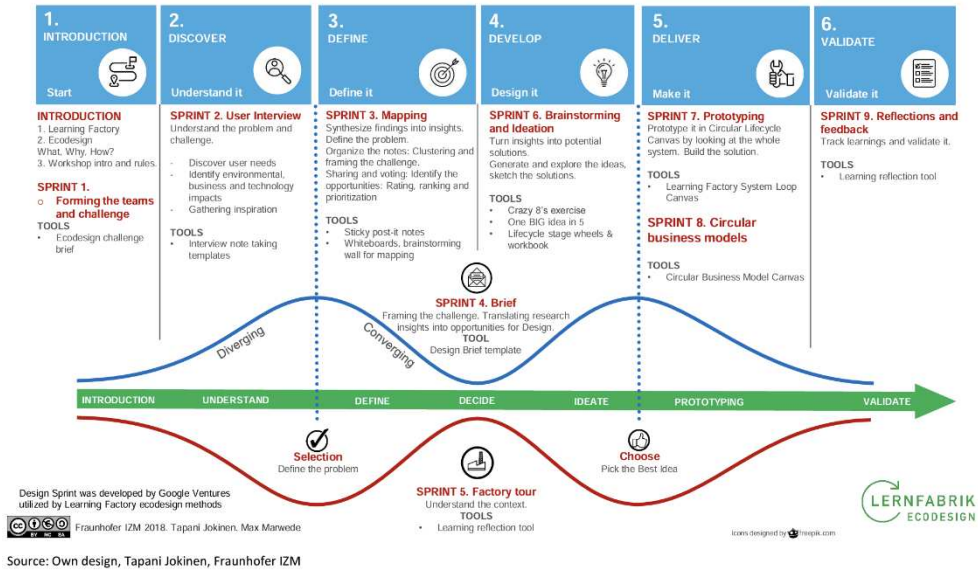
activation of production and consumption loops. Indeed, the circularity model builds upon three main value retention loops: user-to-user, user-to-business, and business-to-business, all developed according to different circular processes; these are grouped into five categories (from the most impactful to the least): (1) Reduce by design; (2) Refuse, Reduce, and Reuse (user-to-user); (3) Repair, Refurbish, and Remanufacture (user-to-business); (4) Repurpose and Recycle (business-to-business); and (5) Remining and recovery of energy. Moreover, as Moreno, Ponte, and Charnley (2017) highlight, the *Circular Design Guide* does not help designers to clearly and undoubtedly identify those concepts that meet CE aspects. From an academic point of view, it does not include valuable literature on Design for Sustainability, which conceptually and operatively anticipated Circular Design (Moreno et al. 2016).

EcoDesign Guide

EcoDesign Circle was an Interreg Baltic Sea Region project (2016–2019), which, thanks to an international group of design centers, government agencies, academic institutions, and industry professionals from Germany, Estonia, Finland, Lithuania, Poland, and Sweden, improved the understanding and use of the design approach to CE. Three main objectives were highlighted; the first concerning business, to enhance the capability of Small and Medium Enterprises to make use of ecodesign; the second is about territorial development, to improve the Baltic Sea Region-wide cooperation between design centers; the third referring to education and training; to increase the capacity of designers in the environmental dimension of design. In 2019, EcoDesign Circle 4.0, an extension of the original project, was funded. Eight partners, including a new partner from Russia, modified and promoted several workshop formats and tools created in the first phase, including the EcoDesign Sprint. The project, which concluded in May 2021, was composed of several relevant activities; the most interesting for our discussion are the Learning Factory and the EcoDesign Sprint methods and tools. These are provided under an open-source license through the online platform Sustainability Guide, alongside practical use cases and more information about the CE. A workshop manual has also been prepared to facilitate training sessions and is available for download.

The EcoDesign Sprint, developed by Design Forum Finland, is an intensive three-day training and acceleration program for design firms and SMEs that want to create concepts of circular products/services. The Sprint brings together a multidisciplinary team of experts to concentrate on the SME's business opportunities through circular thinking. The workshop is based on the Double Diamond DT approach, including its four phases: discover, define, develop, and deliver. Participants, supported by experts, use the developed tools working on a fictional use case, starting from "the initial investigation of the impact and needs around a current situation or problem statement."[3]

[3] https://circulardesign.tools/workshops/.



Source: Own design, Tapani Jokinen, Fraunhofer IZM

Figure 1: EcoDesign Sprint
Source: Design Forum Finland

The following example will deepen the Design Sprint approach and Circular Business Model.

The Circular Sprint

The review of the Design Sprint in the key circular proposed by Santa-Maria, Vermeulen, and Baumgartner (2022) in the Cresting Circular Economy European project is mainly based on the transition from Business Model to a Circular Business Model (Ellen MacArthur Foundation 2014), rooted, therefore, in CE strategies. Circular Business Models (CBM) can be defined as Sustainable Business Models that specifically aim at solutions for the CE through a circular value chain and stakeholder incentive alignment (Geissdoerfer, Vladimirova, and Evans 2018). "The process of creating a business model which embeds implements and capitalizes on CE practices is known as circular business model innovation (CBMI) (Bocken et al., 2019)" (Santa-Maria, Vermeulen, and Baumgartner 2022, 2). DT is considered very useful to ease and support this evolution because it facilitates the organization of multistakeholder collaboration and experimentation process, the collection of system-wide insights, supporting ideation, testing, and refinement; however, DT approach does not consider CE strategies, the generation of sustainable outcome and planning of solutions at the BM level (Santa-Maria, Vermeulen, and Baumgartner 2022). Guldmann, Bocken, and Brezet (2019) propose adopting a systemic perspective because it helps go beyond DT user-centeredness and covers systems and value chain collaboration. Moreover,

Kagan et al. (2020) propose adding an introductory stage in the DT process to better present CE principles and inspire action.

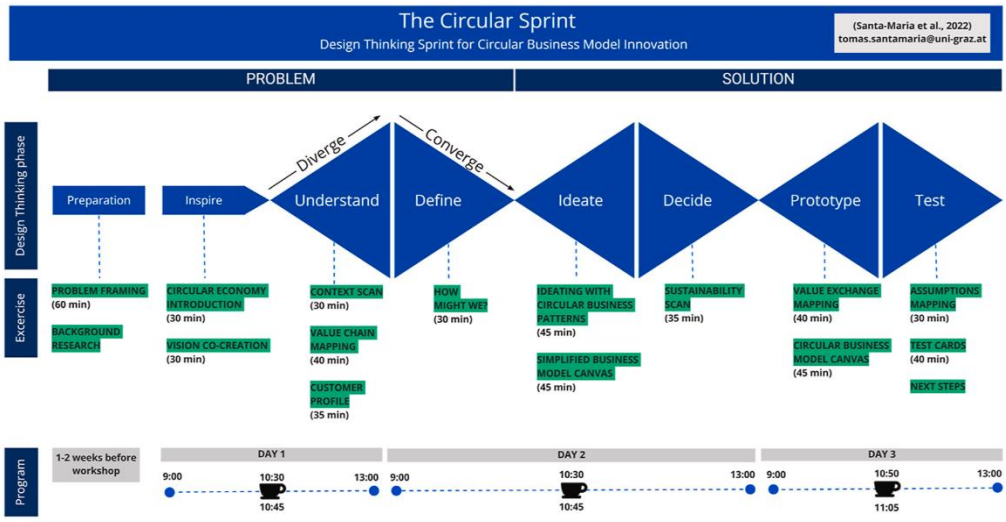


Figure 2: The Circular Sprint
Source: Santa-Maria, Vermeulen, and Baumgartner 2022

When the CD-TOOLS project was started, the Cresting (CiRcular Economy: SusTainability Implications and guidING progress) European project (2018–2021) was ongoing, and the CD-TOOLS project consortium was not aware of it. It is interesting, though, that both projects were based on similar assumptions and used similar approaches.

Santa-Marta, Vladimirova, and Evans's (2022) proposal starts from two main challenges: time efficiency and the use of a digital collaboration environment.

As the first is concerned, time is a fundamental resource in innovation processes, and the Design Sprint method (Magistretti, Dell'Era, and Doppio 2020; Mendonça de Sá Araújo et al. 2019) is rooted in the idea of optimizing time, speeding up the DT process to be developed in five days (in the reviewed model, four days) going from the problem framing to the user-test phases. The limited time available in practice is a fact (Eisenhardt and Brown 1998), but this limitation has been seen as essential for an innovation's success (Santa-Maria, Vermeulen, and Baumgartner 2022).

The Circular Sprint model (or Design Thinking Sprint for CBMI) is composed of seven DT phases (plus one of preparation at the beginning and one of presentation at the end which are shaded in the following table) that correspond to specific activities (Table 2).

Table 2: Phases and Activities Composing the Circular Sprint Model

DT Phase	*Activity*
Prepare	Problem framing, background research
Inspire	CE introduction, vision co-creation
Understand	Expert lightning talks, context scan, actor system mapping, value chain mapping, customer profile
Define	How might we?
Ideate	Ideating with CBM patterns, simplified BM canvas
Decide	FSSD SWOT, sustainability scan,
Prototype	Value exchange mapping, CBM canvas
Test	Assumptions mapping, test cards
Present	Present pitch

Source: Santa-Maria, Vermeulen, and Baumgartner 2022

Looking at the canvases proposed in the Circular Sprint online toolkit, it is unclear what the authors declared as the centrality of developing a Circular Business Model to design products/services. At the same time, the main focus is the generation of circular ideas. We will not deepen the results of the testing phases that the Circular Sprint model underwent. However, it is interesting to mention the experts' opinion on the poor effectiveness of the toolkit for the "generation of outputs at the business model level" (Santa-Maria, Vermeulen, and Baumgartner 2022, 7), which confirms our initial doubts. Indeed, the proposed canvases rely very much on the user's capabilities, especially regarding time management. Even if the preparation phase is thought to be developed two weeks before the real start of the Circular Sprint, five days might be too short length of time to be really effective, especially for a deep change of mindset as the adoption of a circular approach requires.

Systems Mapping

Sustainability can be more thoroughly explored throughout the innovation process by including a systemic approach early on. Wilkerson and Trellevik (2021) recently focused mainly on the problem definition phase of the design process integrating DT and systems mapping approaches according to the SOI goals presented earlier.

Systems mapping is frequently regarded as a tool for putting systems thinking into practice; it is a participative method for developing a common understanding of and communication about a complicated topic (Videira et al. 2010). Systems mapping contains a toolbox of activities that may be used in various stakeholder contexts (Hovmand et al. 2011) to elicit an understanding of a complex problem, identify leverage points for intervention,

etc. In contrast to DT, systems mapping adopts an aggregated viewpoint, addressing the user-focused limitations and offering a "zoom-out" view of an issue. The systems mapping activity occurs in the first divergent phase of the DT process, and it is intended to immediately provide nonexperts with an aggregated and dynamic perspective on their sustainability issue, although it is less deeply detailed than other methods. The facilitation guide "Initiating and Elaborating a Causal Loop Diagram" in Scriptapedia (Hovmand et al. 2011), served as the foundation for Wilkerson and Trellevik systems mapping exercise. The resulting system's maps show the connections between the system's main variables and delineate the system's boundaries, or the issue space, as they relate to the critical variable. The systems map Wilkerson and Trellevik's work becomes one of several inputs used in the DT exercises that compose the whole process. The systems map participants create offers a fresh viewpoint that can complement and challenge the traditional sympathetic, human-centered perspective of DT (Wilkerson and Trellevik 2021). The test exercises were conducted online, using Zoom and Miro, and involved bachelor's degree students; one was focused on business, while the other was on education and lasted two hours.

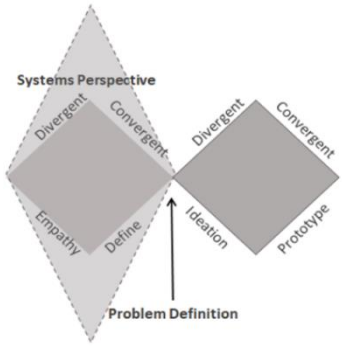


Figure 3: Use of a Systems Perspective and System Mapping in Double Diamond Model
Source: Wilkerson and Trellevik 2021

Compared to the other case studies, Wilkerson and Trellevik (2021) are very specific to one phase and one unique tool to address SOI goals. However, it improved communication throughout the team, playing the role of boundary object, and helped everyone comprehend a complex issue; moreover, the generated system map can be used and reviewed throughout the entire design process.

In the following section, we will highlight the principal insights derived from the discussion provided.

Requirements and Limitations

Before presenting the CD-TOOLS case, we sum up the main limitations of DT, supported by other research and studies. As already mentioned, circular product-service solutions require managing complexity, considering the multiple variables and externalities that characterize a CE context. For this reason, combining DT with Circular and Systemic Thinking becomes crucial, as highlighted also in the Systemic Design Framework developed by the Design Council. Systems thinking can assist the creation of the design brief and subsequent design interventions; this also means that the design problem area should be identified and articulated as a system. Designers will gain an advantage from a perspective that enables them to handle sustainability (and especially circularity) issues in this way. Tools, approaches, and procedures that designers are already familiar with can enable capturing and organizing the design space as a system; the key is to apply them in a novel way (Darzentas and Darzentas 2015).

Said that CE requires DT because it crosses multiple fields. Moreover, local and sector-specific characteristics must be considered closely. There's a need for more profound knowledge about how the innovation process is carried through to facilitate circular change. This know-how has to be acquired both by design students and by professionals already operating in the market.

In particular, circular design tools offer valuable frameworks and methodologies but have limitations. Here are a few:

- Complexity: Because systems and supply chains are interrelated, implementing circular design principles can be challenging. Collaboration and coordination across many stakeholders, including designers, manufacturers, consumers, and legislators, are necessary to realize a fully CE.
- Lack/Excess of Standardized Frameworks: Because circular design is still a relatively new idea, there are few established frameworks and best practices available. The increased focus on sustainability in recent years (from both an economic and a political standpoint) has supported the proliferation of studies and tools that frequently reproduce identical pieces of research that still need to be integrated.
- Technological Limitations: Some circular design concepts rely on cutting-edge technologies, like material recycling and remanufacturing procedures, which may need to be more widely used or commercially viable. Due to limited technical breakthroughs, circular design solutions may need more applicability and scalability.
- Consumer Behavior: Circular design strongly emphasizes encouraging reuse and extending the life cycle of products. However, the effectiveness of circular models is significantly influenced by consumer behavior and preferences. The

potential influence of circular design methodologies may be constrained if consumers are unwilling to engage in actions like repair, reuse, or sharing.

- Economic Viability: Adopting circular design principles may require significant up-front expenditures and alterations to current business strategies. Although circularity's long-term advantages, such as less resource consumption and waste, might result in cost savings, the transition's immediate costs and dangers might discourage some organizations from using circular design concepts.
- Global Systemic Challenges: Circular design frequently focuses on specific products or processes, but it could need to address more general systemic issues like excessive consumption, international supply chains, and socioeconomic inequality. Beyond the capabilities of circular design tools alone, these complicated problems demand all-encompassing solutions.

Despite these limitations, circular design tools and approaches still hold great potential for driving positive change and promoting sustainability. It is important to recognize these limitations and work toward addressing them while leveraging the strengths of design methodologies.

CD-TOOLS: Circuloop and the Circular Design Journey

CD-TOOLS[4] is a project funded by the Lithuanian government, focusing mainly on training and mentoring in support of local entrepreneurs and design professionals to design circular product-service solutions. The project is led by the Kaunas Technology University (KTU), involving the School of Economics and Business and the Faculty of Mechanical Engineering and Design in collaboration with the Institute of Environmental Engineering and other KTU scholars and the research and design agency CRITICAL + Xwhy, with the scientific collaboration of the Design Department of Politecnico di Milano (POLIMI).

The project was conceived to overcome three main challenges for the CE: (1) the cultural and professional transition from a linear to a circular design–production–distribution model; (2) the knowledge exchange between the various stakeholders involved in circular strategies; and (3) the relationship between circular design strategies and the infrastructure that enables prototyping and rejuvenating processes (repair, rebuild, recycle, replace)—the culture of product integrity. The principal outputs of the research project CD-TOOLS are the circular design journey (CDJ) program and the circuloop platform. The platform was conceived to connect businesses, research institutes, and other stakeholders to develop fresh CBMs and advance circular design principles; it is also the digital space where participants in CDJ find

[4] This research project is funded by the European Regional Development Fund according to the 2014 to 2020 Operational Programme for the European Union Funds' Investments, under measure No. 01.2.2-LMT-K-718 activity "Research Projects Implemented by World-class Researcher Groups to develop R&D activities relevant to economic sectors, which could later be commercialized."

all the training materials and canvases to use, where they have their personal page to collect their materials and resources.

The CDJ was developed based on an evolved model of Double Diamond, Triple Diamond, as in the case of Circular Design Sprint. According to this, the prototyping phase is not the final step of the design process.

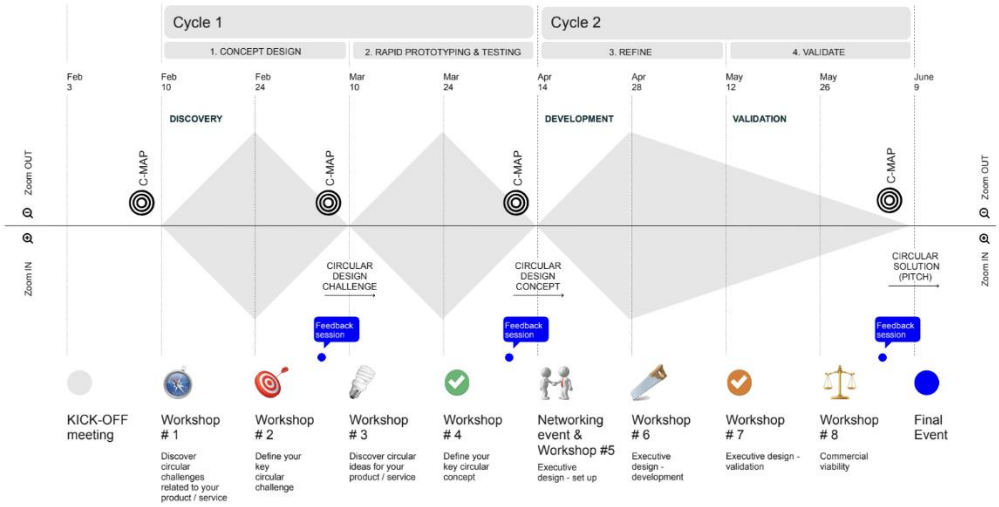


Figure 4: CDJ
Source: CD-TOOLS 2023

CDJ encompasses the circular design process and related strategies, CBMs, inter and transdisciplinary intellect, and systems thinking. It includes two cycles. The first focuses on concept design, rapid prototyping, and testing; the second focuses on fine-tuning and validating it. CDJ consists of eight workshops (plus a kick-off and final events) correlating to the various stages of developing a solution from the initial idea. During the workshops led by mentors and facilitators, who describe how to use the relevant tools, the participants are supported by a set of canvases, designed considering the operating model they were based on, the user behavior to be changed or stimulated, and the network of actors (human and nonhuman) to be considered. The canvases were custom-designed to support the work to be done in each CDJ workshop. The start of the journey and each convergent phase are supported by the development of a Circular-Map (C-Map), which is a simplified model of a Gigamap but more structured and guided than a systems map. The creation of the C-Map is supported by a survey called Product Idea Template (PIT).

Participants have access to a vast catalog of resources, both educational (training online and offline), material (access to makerspace, selected projects will receive additional financial assistance), and human; indeed, they are mentored throughout the whole process, and they

also receive additional consultancy by experts on the topics they need most. Compared to other Product Development Programs, CDJ pays specific attention to the principles of circular design integration in developing a product-service system.

The pilot edition of the CDJ ran from February to May 2023. The participants were selected by an open call using a shared evaluation framework. The commission paid attention to the idea's maturity level (both early-stage and more mature) and the declared circular innovation challenge; these two selection criteria helped apply a backcasting approach. Moreover, in the selection process, others had the possibility to apply different circular strategies to the idea and the organization structure (teams were preferable over a singular person).

At the time of writing, the eighteen selected teams (or professionals) from Lithuania are attending the CDJ. Therefore, we have yet to provide an evaluation of their experience. We will focus mainly on the development phase and characteristics of the CDJ and its tools in the conclusive section, especially in relation to DT and Double Diamond approach.

Conclusions

As previously said, DT and Double Diamond model present several limits, as well as design tools and methods. The experimentation with the CD-TOOLS project asked us to renovate the traditional DT approach to avoid its limitations. The project, through the CDJ and circuloop platform, mainly addressed the following[5]:

- Lack of a long-term perspective; this weakness is influenced by at least three main aspects that we are going to rapidly address. The first is the time dedicated to the development of a circular solution; in contrast with respect to other journeys, CDJ has been thought of as a process that lasts four months. The second is the target(s) involved. CD-TOOLS project wanted to focus especially on professionals, beyond students, because of the importance of continuing professional development and also for helping already existing businesses in achieving the environmental transition goal. The third is the use of a backcasting approach, which starts from an already existing intention on what are the objectives that the designer/entrepreneur wants to achieve in regard to an idea of a product/service that might already exist and need to be redesigned according to circular principles; for this reason, for example, CD-TOOLS developed a self-assessment tool called Product Idea Template (PIT) so that the participant was able to assess the current state of the idea and identify the gaps between the present and the desirable future, as well as being able to zoom out and have a wider perspective on their work objectives and impacts;

[5] In the time of this article writing, CD-TOOLS is testing the CDJ and the platform has not been implemented yet.

- Contextual and sectoral approach; circuloop platform and the CDJ were initially developed for the Lithuanian market; they can even be scaled in other contexts. However, the contextual and the sectoral frameworks are particularly relevant because of the different environmental and business policies operating in specific countries, which often differ from others. For example, extraction and disposal policies are different from country to country (often even from region to region); but also, the possibility to use particular technologies and materials and their commercialization may differ very much, as—for example—in the food industry;
- Cross-disciplinary collaboration; this is already incentivized in DT processes; however, CD-TOOLS integrated this approach since the very beginning of the methods and tools ideation and development. The adaptation of the DT tools with the requirements of CE has mainly performed, thanks to the adoption of a co-creation approach through the collaboration of scholars and professionals from different fields (design, management, economics), and it was intended to bridge the gap between research and practice;
- Need to go beyond human-centeredness; this can be achieved by taking into consideration nonhumans not only in the impact of the proposed product/service but also in the needs definition, adding nonhuman personas in the picture;
- Deepening knowledge and operational guidelines; to achieve this goal, CD-TOOLS project created both online and offline tutoring and training resources; not only tools but also learning modules will be available on the circuloop platform to conceptually inform and equip the participants with the necessary skills for the CDJ.

Future research efforts should focus on evaluating the effectiveness of the CDJ and circuloop platform, particularly among entrepreneurs and professionals, as the target audience. Additionally, considering the varying systemic challenges across different localities, the scalability and adaptability of CDJ and circuloop platform to other countries remain important considerations. It is crucial to continue investigating the potential of circular design innovation and address the existing limitations as research progresses.

Acknowledgment

We want to thank Professors Rūta Valušytė, Lina Dagilienė, and Jolita Čeičytė-Pranskūnė and the whole team from the Kaunas University of Technology, project leader of CD-TOOLS.

AI Acknowledgment

Generative AI or AI-assisted technologies were not used in any way to prepare, write, or complete essential authoring tasks in this manuscript.

Informed Consent

No need for informed consent.

Conflict of Interest

The authors declare that there is no conflict of interest.

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