# Design Thinking Tools to Catalyse Sustainable Circular Innovation

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Edited by Hanna Lehtimäki, Leena Aarikka-Stenroos,
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*Edited by Hanna Lehtimäki,*
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# DESIGN THINKING TOOLS TO CATALYSE SUSTAINABLE CIRCULAR INNOVATION

*Nancy Bocken, Brian Baldassarre, Duygu Keskin, and Jan Carel Diehl*

## Introduction

In recent years, 'design thinking' emerged as a new approach for organisations aiming to solve complex and open-ended innovation problems. Innovation management scholars have discussed this extensively (Brown, 2008; Kimbell, 2011; Liedtka et al., 2013; Martin, 2009; Stacey et al., 2000). According to Brown (2008), design thinking is an iterative and experimental approach to develop innovations that are desirable for people, financially viable, and technically feasible for organisations. Boland and Collopy (2004) stated that managers should learn to think in the way designers think, approaching business problems in a more holistic and open-ended way. The British Design Council (2007) and Plattner et al. (2009) proposed a conceptual design thinking model. Making an additional step, Liedtka and Ogilvie (2012) listed ten design thinking approaches and tools that can be leveraged to operationalise the conceptual model (e.g., rapid prototyping and journey mapping).

In parallel, design thinking approaches have been increasingly discussed also for addressing complex challenges, with a specific focus on achieving sustainable development and a circular economy (CE) (e.g., Baldassarre et al., 2019a; van Dam et al., 2020). Circular innovation is about the technology, product, value chain, business model, and ecosystem changes to break away from a linear economy paradigm where products are disposed of after a limited number of uses, to a system where products and materials are reused, and the natural environment is regenerated. Several scholars claimed that design thinking can and should play a significant role in transitioning to a CE by rethinking not only industrial products and processes, but also the businesses and socio-technical systems around them (Dobers & Strannegård, 2005; Papanek, 1971). Ceschin and Gaziulusoy (2016) suggested that it can be instrumental in designing business models to enable and foster a CE. Baldassarre et al. (2020a) proposed a framework to implement existing sustainable design thinking theory into business practice at four levels, from products to business models and collaborative ecosystems, as well as a design thinking process for industrial symbiosis (Baldassarre et al., 2019b). Diehl and Christiaans (2015) highlighted the changing role of designers from the creation of industrial products to co-creating sustainable business models with multiple stakeholders and integrating their various demands and proposed several tools for

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developing future-oriented scenarios and roadmaps and visualising potential solutions to create a shared understanding among team members and stakeholders.

Despite these developments, how design thinking can be concretely leveraged by organisations to perform circular innovation and more broadly catalyse the transition toward a more sustainable society remains relatively under-explored. Although there is now a better understanding of how design thinking and proposed tools can be used for addressing complex innovation problems (Dorst, 2011; Liedtka et al., 2013), we still know little about how these tools can contribute to the development of sustainable and especially circular innovations (e.g., Bocken et al., 2021a). Research in this regard is emerging rapidly. For example, Brown et al. (2021) proposed a design thinking tool to support multiple organisations in collaboratively ideating a circular value proposition, while Bocken et al. (2021a) explicitly stated that design thinking tools can be leveraged to ensure desirability, feasibility, and viability of circular innovation, without, however, diving into this specific subject. This research has the potential to be concretely applied by organisations and accelerate the transition to a CE. However, for the time being, it is in its infancy. Aiming to advance it, with this chapter we explore the following research question: How can design thinking tools catalyse sustainable circular innovation?

We address this question by first reviewing the contemporary conceptualisations of design thinking, mapping the extant tools, and consequently illustrating how these tools have been applied in several sustainable and circular innovation projects. This is functional to build on former research (e.g., Guldmann et al., 2019; Prendeville & Bocken, 2017) and explain with more specificity when and how design thinking tools might be applied to develop sustainable circular innovations that are simultaneously desirable for people, and financially viable and technically feasible for businesses.

## Conceptual background

### *What is circular economy innovation?*

Circular innovation is about developing and making conscious changes to technologies, products, value chains, business models and ecosystems to support the move away from a linear 'take-make-dispose' paradigm to a system where products and materials are continuously reused, and nature is regenerated (Brown et al., 2019; Rashid et al., 2013). Key strategies include slowing, closing, narrowing, and regenerating resource loops (Bocken et al., 2016a; Konietzko et al., 2020). Slowing the loop is about long-life products and design for product life extension, supported by design for attachment and trust (emotional durability), and reliability and physical durability (Bocken et al., 2016a). For example, several companies selling anything from clothing to furniture and household equipment, are including a lifelong warranty to ensure longer use of their products (see e.g., Button, 2018 and buymeonce.com). This is often accompanied by a more premium business model to make this 'value over volume' model viable. Closing the loop is about recycling, which may be facilitated by designing for a technological or biological cycle (McDonough & Braungart, 2010) and easy dis- and reassembly. Recycling is a widely known practice for household waste and packaging. However, there is still ample work to do, because in 'leading' places like Europe recycling of household waste, packaging and electronics is still below 50% (2016 data, European Environment Agency, 2021). Narrowing the loop is about using less material or resources per product or service. For example, smaller shared cars use less fuel and require less cars in total. Since 2013, the car-sharing company DriveNow has made available the small electric BMWi in its sharing model in several German cities. Regenerating is about cleaner loops and ensuring the environment is in a better state than how it was found (Bocken et al., 2021b). For example, companies like Nestlé and Unilever are working on biodiversity issues such as reviving bee populations and regenerating the soil together with collaborators to secure their future supply of ingredients such as strawberries and tomatoes for their products (Bocken & Geradts, 2022).

Developing innovations for the CE is a complex endeavour, as they are embedded in a larger innovation system and influenced by a multitude of factors, such as technological and market developments and the institutional environment, including norms, values, culture, and policies (Buhl et al., 2019; Han et al., 2022). Therefore, it is often challenging to develop and implement sustainable circular innovations for several reasons. First, circular innovation requires organisations to think differently due to increased product responsibility (Bocken et al., 2016a). It requires them to consider the whole life cycle of products (Den Hollander et al., 2017), as well as the related infrastructure and actors to enable slowing, closing, narrowing, and regenerating resource loops (Konietzko et al., 2020). Second, to develop desirable, viable, and feasible circular strategies, the needs and values of different users and stakeholders must be understood more deeply (Guldmann et al., 2019). Third, the most relevant circular principles and strategies for the company need to be identified and implemented (Sumter et al., 2018), and the innovation outcomes from environmental, social, and economic perspectives need to be assessed (Santa-Maria et al., 2021). Finally, even if a product is designed with the intent of increasing efficiency and reducing negative environmental impacts, rebound effects might occur (Castro et al., 2022; Chitnis et al., 2013; Zink & Geyer, 2017). In practice, this means that a positive environmental impact is not achieved because the efficiency gains are lost due to other unexpected factors. A simple example to illustrate the concept is the installation of a more energy-efficient light bulb, which leads users to a less careful behaviour and ultimately to higher energy consumption. Another example could be a car-sharing service that optimises the use of vehicles but at the same time encourages to drive more instead of walking short distances. The best designs would seek to build in mechanisms to avoid such rebound effects where possible.

### *What is the role of design thinking?*

Design thinking has gained popularity as a new paradigm for dealing with problems in various domains and professions, such as information technology, innovation, and business (Dorst, 2011) and more recently, sustainability and CE (e.g., Ceschin & Gaziulusoy, 2016; Guldmann et al., 2019; Sumter et al., 2018). For example, design thinking can catalyse circular innovation through the creation of products that can be disassembled and recycled (Vanegas et al., 2018), or through a more environmentally conscious material selection (Virtanen et al., 2017). Also, design thinking can contribute to a CE by influencing user behaviour (Wastling et al., 2018), and integrating business model considerations (Bocken et al., 2016a). In this respect, design thinking as a user-centred, collaborative, and iterative approach is considered to be highly relevant for circular innovation (Guldmann et al., 2019). Moreover, the role of designers needs to change more profoundly, for example, towards designing for multiple life cycles, assessing, and comparing the environmental impact of different circular strategies, engaging users in the use and return of products, and understanding the interlinkages between the product and the business model (Bocken et al., 2016a; Sumter et al., 2020). Next, we discuss the core aspects of design and then introduce our conceptual framework for mapping the extant design thinking tools proposed by several scholars.

Design thinking, as popularised by management scholars, can be understood as a problem-solving approach that "uses designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity" (Brown, 2008, p. 2). Three important aspects come forward in this definition: 1) the designer and his/her way of thinking and acting, 2) the success criteria of a design, and 3) the design process.

The first aspect is the designer or design thinker, who is argued to have a different way of thinking than, for example, a manager (Boland & Collopy, 2008). Cross (1982), in this regard, referred to "designerly ways of knowing", as the way that designers operate to first understand and frame the problem they are dealing with, and then move on to approaching it and solving it. Lawson (1980) and Schön (1983) extensively explored the way designers think and act as well. In turn, management scholars attempted to better understand how the main insights of these seminal pieces of literature could be useful in other contexts of business innovation, strategy, and organisational design (Brown, 2008; Hassi & Laakso, 2011). Several definitions of what constitutes design thinking, design thinking principles, and related skills and practices have been proposed within the design and management discourse. According to Brown (2008), for instance, the characteristics we should look for in design thinkers are empathy, integrative thinking, optimism, experimentalism, and collaboration. Hassi and Laakso (2011) distinguish between practices, thinking styles, and mentality in conceptualising design thinking. The authors propose: 1) a human-centred approach, thinking by doing, visualising, combining divergent and convergent approaches, and collaborative work style as design thinking practices, 2) reflective framing, abductive thinking, taking a holistic view and using integrative thinking as design thinking styles, and 3) experimental and explorative, ambiguity tolerant, optimistic, and future-oriented as design thinking mentality. In a similar vein, Diehl and Christiaans (2015) highlight the expanding role of designers by expanding the traditional skill set of designers to include human-centeredness, experience design, future-orientedness, visualisation, and integration. Furthermore, the design process is often co-creative involving frequent interactions with multiple customers and stakeholders (Guldmann et al., 2019).

The second aspect includes the criteria to define the success of a design. These aspects include desirability, feasibility, and viability (Brown, 2008; Martin, 2009). The desirability criterion refers to what people need and/or want; feasibility refers to what is doable from a technical, technological, and/or operational standpoint; viability refers to what is possible financially and/or economically for the innovating organisation (Calabretta et al., 2016). These three criteria are central to design thinking and relevant to circular and sustainable innovation as well (Baldassarre et al., 2020b). Besides these three criteria, circularity is a crucial criterion for circular innovation, which requires business organisations to focus on retaining the value embedded in used products by narrowing, slowing, closing, and regenerating resource loops (Bocken & Geradts, 2022; Guldmann et al., 2019). Therefore, following the logic of design thinking and applying it to sustainable circular innovation, we define four criteria for sustainable circular innovation development, namely desirability, feasibility, viability, and circularity.

The third aspect is the design process, which uses the desirability, feasibility, viability, and circularity criteria to create customer value or market opportunity. Several design thinking process frameworks explain what constitutes a design process. Brown (2008) conceptualises the design process as a system of spaces rather than a predefined series of orderly steps. The three spaces proposed are inspiration, ideation, and implementation. Ries (2011) discusses the iterative steps of building, measuring, and learning in the Lean Startup approach. In a similar vein, several frameworks conceptualise design processes for sustainable or circular business model innovation. Frankenberger et al. (2013) define the process stages of business model innovation. These entail initiation, ideation, integration, and implementation of new business models.

Finally, the fourth aspect relates to the level of innovation: at the technology, product, business model, or ecosystem level (Konietzko et al., 2020; Rashid et al., 2013). Whereas designers have been involved in technology and product design, the interaction between products, services, and business models is becoming a more prominent area of work in business and design research and practice (Diehl & Christiaans, 2015). The reason is that a business model determines the impact of a product in terms of customer success (Chesbrough, 2010), and environmental impact (Tukker, 2004). Design is even linked to supporting the transition of broader ecosystems, to circular cities through redesigning the products and business models used in the cities and using design thinking to realise new projects (Prendeville et al., 2018).

## Method

In this section, we describe the method employed to address the research question of how design thinking catalyses sustainable circular innovation. We identified a set of relevant sources presenting a wide spectrum of design thinking tools. These sources included primarily the books *This Is Service Design Thinking* (Stickdorn et al., 2011) and *The Delft Design Guide* (van Boeijen et al., 2020), as they emerge from the need for a comprehensive overview of perspectives and tools to guide designers in the development of products, services, and other creative processes and are being used for both educational and practical purposes around the world. We consulted these sources in combination to derive a selection of five essential design thinking tools that we found to be commonly used in design innovation practice (Table 18.1). In parallel, we identified a set of relevant sources presenting design thinking tools that can be used specifically to innovate for circularity. These sources are included in the review by Bocken et al. (2019), including an overview of circular business model tools and later tools at the intersection of CE developed by the authors. Initial tools were selected from the review by Bocken et al. (2019) to focus specifically on CE and design thinking but were also restricted to the tools that the authors were familiar with and were used with companies in practice. A review by Pieroni et al. (2019) on sustainable and circular business model innovation highlighted over 90 approaches (tools, frameworks, etc.) but of those, only around 50% were experimental rather than theoretical, and only a handful of tools had been used with(in) companies. In this study, the authors drew on tools that encapsulate design thinking and have been applied with(in) companies. We added newer (post-2019 review) tools; circular tools the authors co-developed and applied in practice. These newer added-circularity tools and frameworks include the ones by Baldassarre et al. (2020b), Brown et al. (2021), and Konietzko et al. (2020). We eventually selected five conventional and seven circularity tools. The 12 tools that we selected are briefly described in the following paragraphs and categorised in Table 18.1.

The first five rows of the table show, highlighted in light grey, five essential design thinking tools that we selected, namely: future visioning, personas, system map, service blueprint, and (sustainable) business model canvas. The remaining rows show, highlighted in dark grey, design thinking tools created specifically for circular and/or sustainable innovation, namely: circularity deck, circular collaboration canvas, circular business model pilot canvas, environmental value proposition framework, rapid circularity assessment, product journey map, and value mapping. Although this is not a complete list of all the existing tools that can be used to design in circular and sustainable innovation projects, we selected these because we have worked with them and aim to provide empirical evidence on how they can be applied in practice. Accordingly, in the next section, we illustrate how the tools listed previously can be applied in practice using a set of illustrative cases from sustainable and circular innovation projects (Siggelkow, 2001, 2007; Yin, 2011).

*Table 18.1* Synthetic overview of the design thinking tools and methods, categorised according to sustainable and circular design thinking principles, criteria, phases, and level of circular innovation

| | *Sustainable and circular design thinking* | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Tools and methods* | *Principles* | | | | | *Criteria* | | | | *Phases* | | | *Circular innovation* | | |
| | | *Human centred* | *Future oriented* | *Holistic systemic* | *Collaborative* | *Experimental* | *Desirability* | *Feasibility* | *Viability* | *Sustainability, Circularity* | *Ideate, Design* | *Implement, Test* | *Evaluate, Improve* | *Product / Technology* | *Business model* | *Ecosystems* |
| 1 | Future visioning | | X | | X | X | X | | | (X) | X | | | X | X | |
| 2 | Personas | X | | | | X | X | | | | X | | | X | | |
| 3 | System map | | | X | X | | | X | | | X | | | X | X | X |
| 4 | Service blueprint | X | | | X | X | X | X | | | X | X | | X | X | |
| 5 | (Sustainable) Business model canvas | X | X | | X | X | X | X | X | (X) | X | X | | | X | |
| 6 | Circularity deck | X | | X | X | X | X | | | X | X | | | X | X | X |
| 7 | Circular collaboration canvas | X | | | X | X | X | | | X | X | | | | X | X |
| 8 | Circular Business model Pilot canvas | | | | X | X | | X | X | X | | X | X | | X | |
| 9 | Environmental value proposition framework | | | X | X | | | X | | X | X | | X | | X | |
| 10 | Rapid Circularity Assessment | | | X | | | | | X | X | X | | X | X | X | |
| 11 | Product Journey Map | X | | | X | X | X | | X | X | X | | X | X | | |
| 12 | Value mapping | | X | X | | | | | | X | X | | | X | X | X |

*Source*: Based on Brown (2008), Bocken et al. (2019), Ries (2011), Frankenberger et al. (2013), Konietzko et al. (2020), Stickdorn et al. (2011) and van Boeijen et al. (2020).

## Results

### *Tool 1 – future visioning*

Future visioning is a method used for expressing a desired future that serves as a strategic reference point and motivates innovators in an organisation (van Boeijen et al., 2020). A vision aims to establish a tension between 'what is' and 'what could be', to provide long-term direction for innovations. It can be presented using text, drawing, and video content. Future visioning is typically used in the innovation strategy development of an organisation.

One example of future visioning is the case of Sagar Energy Solutions and fishermen on Lake Victoria in Tanzania, which deployed over 600,000 kerosene lanterns for night fishing (see Figure 18.1). These lanterns consume 900,000 litres of kerosene per day. The current solutions have a high negative environmental impact and health risk for the fishermen. Sagar Energy Solutions is a social enterprise developing renewable energy solutions for off-grid communities. To guide their innovation strategy, they developed their future vision: "Transitioning niche and artisanal businesses away from fossil fuels, towards modern and renewable energy solutions" (see sagarenergysolutions.re). This future vision (Figure 18.1) gave directions to the design team that developed a new floating lantern powered by solar energy. This new design will not only eradicate the use of kerosene, but it will also significantly decrease the environmental impact, create a safer and healthier working environment for the fishermen, and pay itself back because of its low operational costs.

### *Tool 2 – personas*

A 'persona' is a fictional profile used to represent a particular user or group to ensure human-centredness in innovation and make sure that such innovation will be desirable (Stickdorn et al., 2011). Personas are usually developed by combining research insights into a visual and textual representation of the archetypical user, encompassing key traits, needs, and wishes, which are functional to catalyse ideation and further design.

In a study on a large UK-based clothing retailer (Miller et al., 2016), the following was investigated: How can sustainable behaviour personas be developed and used to stimulate sustainable business model innovation? As part of the study, five personas were developed based on an initial survey in the UK, which was further enriched through in-depth interviews and video/photographic material. The resulting personas included: Selfish Impulsives (24%), Savvy Economisers (24%), Casually Conscious Customers (19%), Progressive Purchasers (19%), and Committed Caretakers (15%) (Miller et al., 2016). Full-sized personas were used during workshops to stimulate creativity. The personas were designed to avoid stereotyping, but in a way that they looked like real people. By using real faces and matching clothing, the customers came to life more, which catalysed brainstorming because they "felt like real people that we connected to implicitly" and "in a way that business could create and deliver to them" (Miller et al., 2016, p. 15).

### *Tool 3 – system map*

A 'system map' is a visual representation that depicts in a holistic way the entire innovation system, including the stakeholders involved (e.g., customers, organisations, etc.), their interactions (e.g., financial flows and transactions, service exchanges, etc.) as well as boundary objects (e.g., new products, etc.). The result is a map that shows the various socioeconomic actors that form part of the system and their interactions, which becomes more and more detailed as the project

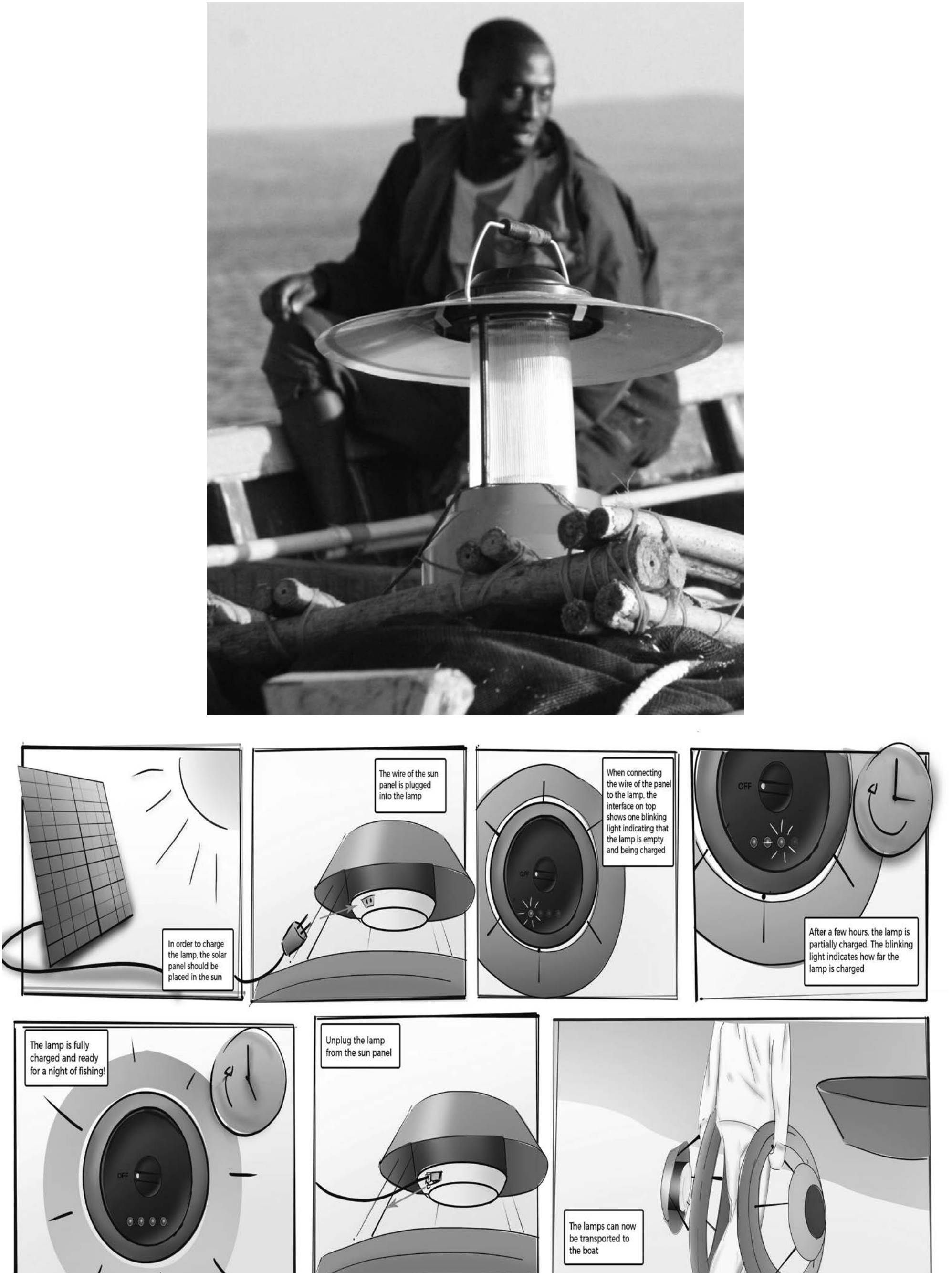



*Figure 18.1* Kerosene lanterns and design of a solar energy-powered lantern as a sustainable alternative driven by the future vision of the company.

*Source*: Blok et al. (2019).

evolves (Vezzoli et al., 2017). System maps can be used to support the (co-)designing and visualisation of the system structure, to keep track of the feasibility of an innovation during the ideation and design phase or to benchmark and learn from similar product-service systems.

To compare the business model of two grocery home delivery companies, a system map of both business models was created. This visual way of mapping information, as well as financial and product flows, made it easy to understand the differences between the two concepts. In Figure 18.2, the system map of the company Pieter Pot (reusable packaging supermarket offering) in which not only the shopping crates are returned and reused, but also the primary packaging is on the left side. The food supplies are delivered in reusable glass pots, which, after emptying, are returned to Pieter Pot, cleaned, and reused by the next customer. On the right side of Figure 18.2 is the system map of a more traditional home delivery by PicNic. The system maps demonstrate clearly that the more circular concept of Pieter Pot also involves more financial, products, and information flows, and more actors.

### *Tool 4 – service blueprint*

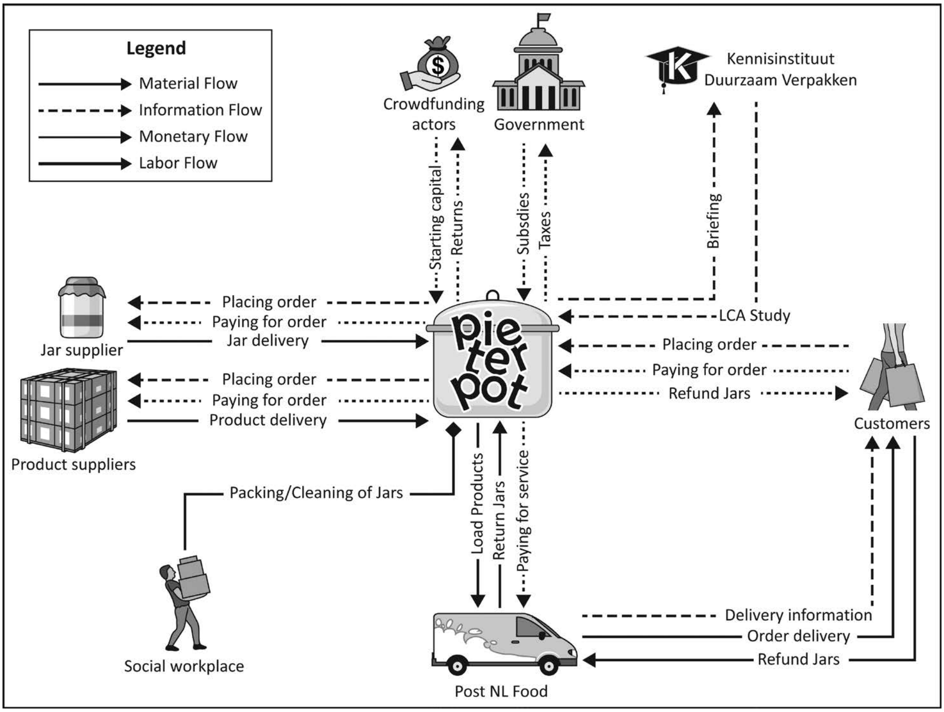
A 'service blueprint' is a visual schematic representation of the sequence of actions that are necessary for a service offering to be delivered (Stickdorn et al., 2011). It incorporates the perspective and actions of users, service provider(s), and third parties (if any), thus fostering *human-centred* and *collaborative* innovation. Service blueprints are typically used to *ideate* and *design* new services, but also to experimentally *implement* and *test* them to mainly ensure their *feasibility*.

In a study in collaboration with Philips Design, the question was: How can we engage hospital patients to send back the Healthdot (a medical device) after home use following hospital discharge, in order to foster a circular service model for the device? The service blueprint was used as a design tool to visualise and discuss with key stakeholders (i.e., patients, the hospital, Philips, etc.) their roles and actions needed for the circular service model to take place. Figure 18.3 visualises this in a service blueprint.

### *Tool 5 –sustainable business model canvas*

A 'business model canvas' (Osterwalder & Pigneur, 2010) is a schematic representation of how a business functions, including details on the value proposition it offers, the targeted customers, relationships, and channels to reach them, key activities, resources and partners, cost structures, and revenue streams. Business model canvases allow to experimentally ideate, design, implement, and test new business model concepts, to ensure that they are desirable for customers as well as technically feasible and financially viable.

Business model canvasses (and the sustainable business model canvas version of it; see Figure 18.4) have been widely used in practice to develop circular business models (Bocken et al., 2018, 2021; Guldmann et al., 2019). The strength of these types of tools is that they bring together the key elements of a business model, starting with the value proposition or product-service offering, elements of value creation (key activities, stakeholders, resources, and capabilities), value delivery mechanisms (e.g., channels), as well as value capture mechanisms (cost structure and revenue streams). Different cases on companies experimenting towards a (more) circular business model, such as Philips, Peerby, and MUD Jeans were mapped according to these different elements to evaluate the changes of aspired business model changes (Bocken et al., 2018). Figure 18.4 includes an illustrative example for 'circular fashion'.



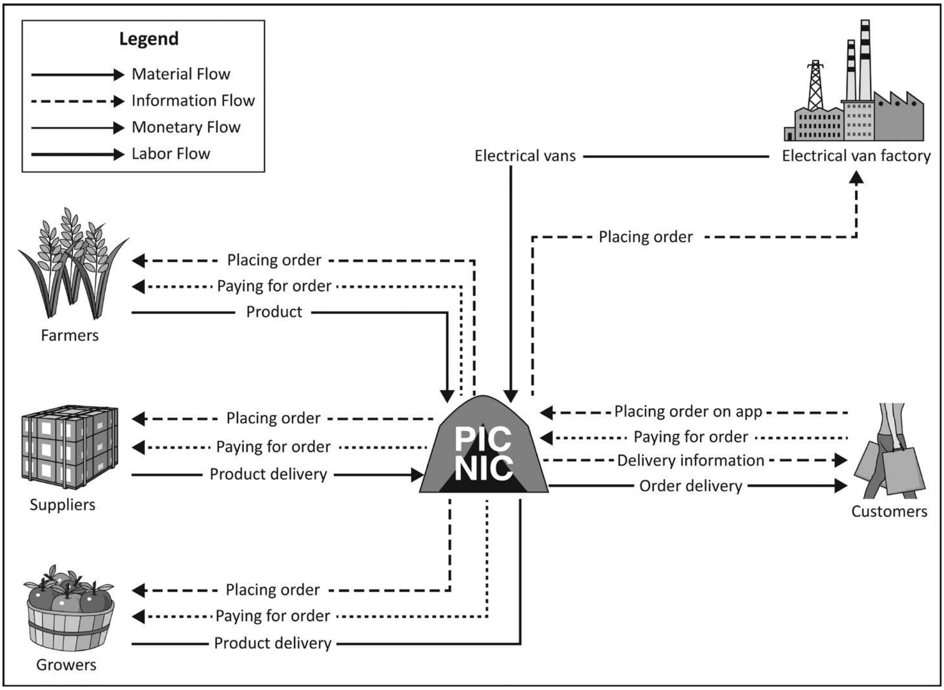




*Figure 18.2* System maps of two different grocery home delivery business models.

*Source*: Ville et al. (2021).

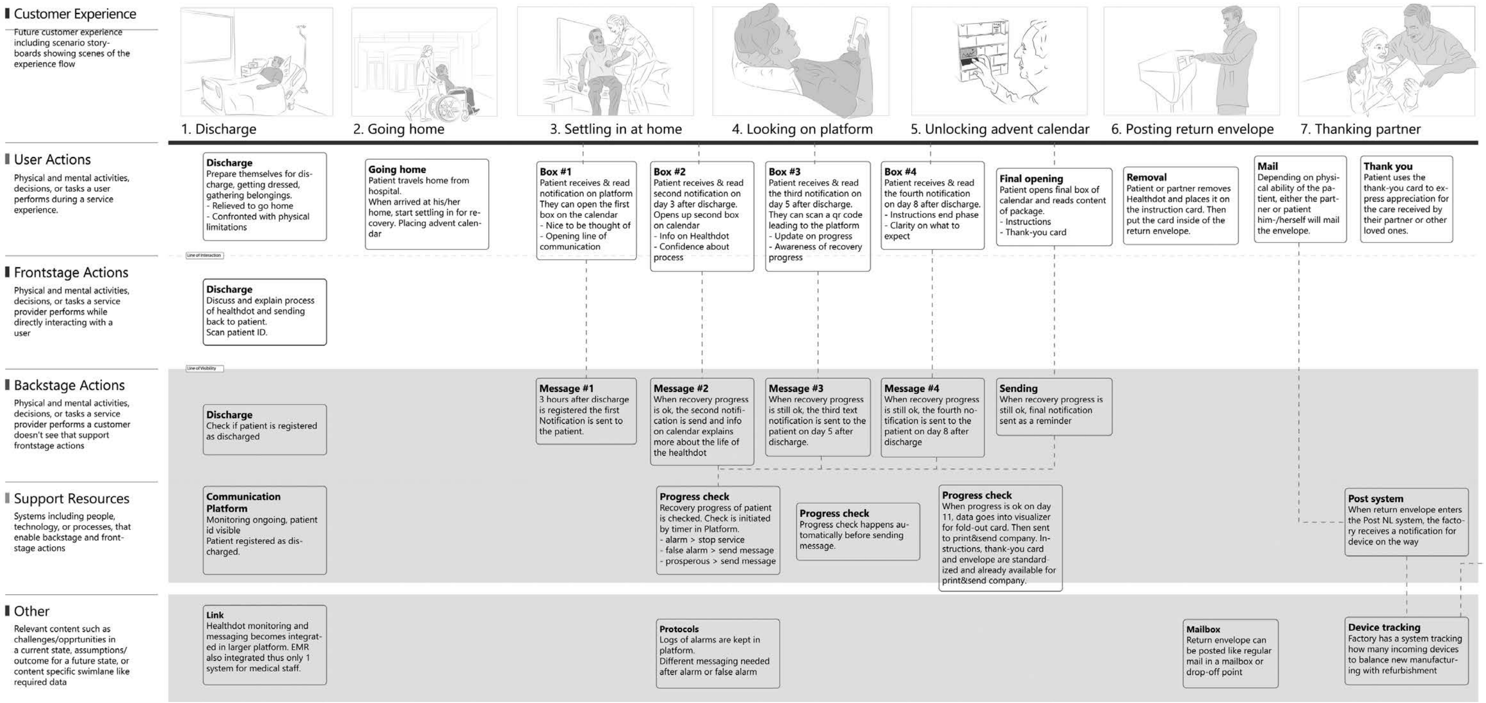



*Figure 18.3* Service blueprint tool applied in a project with Philips Design, supporting the design of a circular service model in a health-care context. For more information, see van Hamersveld (2019).

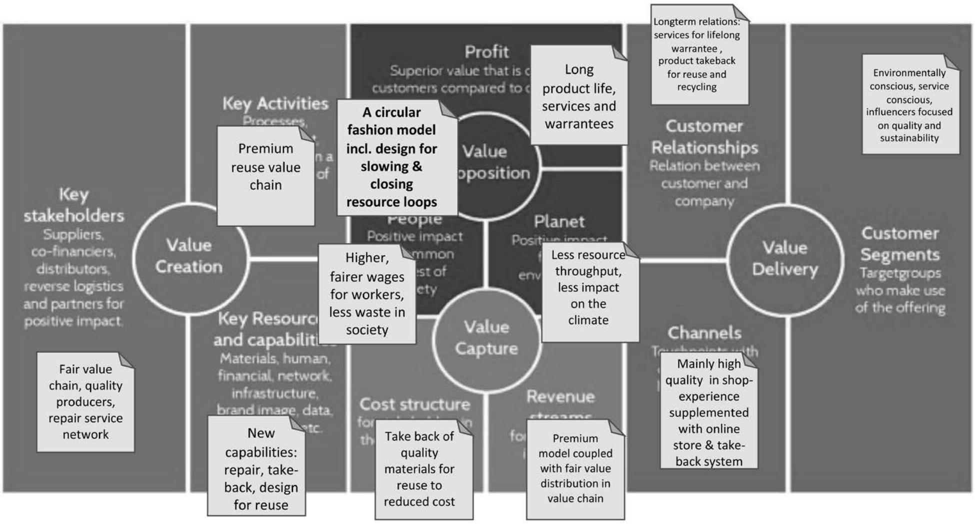



*Figure 18.4* Sustainable business model canvas for circular fashion.

*Source*: Bocken et al. (2018).

### *Tool 6 – circularity deck*

The circularity deck is a set of cards containing different strategies, approaches, and examples to innovate for a CE in a more systemic and collaborative way (Konietzko et al. (2020). The tool is intended to support brainstorming workshop sessions where participants can ideate and design ways to narrow, slow, and close material and energy flows through new products, business models, or cross-organisational interactions. This is important to foster circular and sustainable innovation concepts that are more desirable for business customers and partners.

In a study in collaboration with innovation consultancy Innoboost and the multinational Philips, the question was: How can the lifetime of electronics products for personal care be extended? The circularity deck was used in a physical workshop to facilitate innovators from different departments within Philips in a brainstorming session about multiple possible actions entailing product redesign (e.g., design for repair and refurbishment) as well as changes in the company's business model (e.g., transitioning from a one-off sale to a lease model) and by establishing collaboration with other parties (e.g., delivery companies). The resulting ideas were used internally by Philips to steer the corporate's circular innovation strategy.

The circularity deck may be used in the online platform Miro to facilitate online brainstorming (see https://miro.com/miroverse/circularity-deck). An excerpt of the cards was used for a virtual brainstorm using Miro in a process combined with Lean Startup and effectual thinking, building on what knowledge, networks, and resources are available (Bocken & Coffay, 2022). The aim was to help industry develop CE experiments.

### *Tool 7 – circular collaboration canvas*

This circular collaboration canvas tool is a template containing a set of key questions to trigger collaborating organisations in ideating and designing a joint value proposition for a circular innovation. It is typically used to negotiate key features of the value proposition while negotiating around key challenges, to ensure its desirability and circularity.

In a study in collaboration with Behaviour Works Australia, Monash University, and the Australian Fashion Council, the question was: How can we collaboratively boost circularity in the fashion industry within Australia? The circular collaboration canvas was used in an online workshop setting to help six different (large and small) companies in the fashion industry and one charity organisation to define a collaborative circular innovation idea to be pursued together, within the broader framework of upcoming circularity policies established by the government. The outcome was the creation of *Circular Stories*, a graphic booklet summarising the typical life cycle of an apparel product in the country, complemented by circularity principles and guidelines that may support other companies in collaboratively transforming their supply chains. Figure 18.5 is a snapshot of the canvas used during the workshop, where the participants discussed key questions (e.g., What challenge do you want to solve? How will you improve circularity?) as a way to converge toward the aforementioned outcome.

### *Tool 8 – circular business model pilot canvas*

The circular business model pilot canvas tool is a template that supports experimentally implementing, testing, and iteratively evaluating a circular business idea in terms of a prototype that has to be defined, built, and delivered to customers while generating profit and measuring the circular impact that is achieved by doing so. Due to its nature, it is typically used once a circular business idea has been already defined, mainly to move forward with the validation of its feasibility, viability, and sustainable circularity.

In a study conducted within the EU Horizon 2020 project ‘Zero Brine’ as a collaborative effort with 20 organisations from ten different countries, the question was: What is a possible circular business model for recovering and putting back on the market resources and minerals recovered from industrial wastewater in the Port of Rotterdam? The circular business model pilot canvas was used in a set of 19 individual contacts as well as three collaborative sessions with project partners, in order to iteratively refine the circular value proposition (i.e., What is the idea and the impact?), creation (i.e., How do we make it happen?), delivery (i.e., How does it work?), and capture (i.e., How do we profit?) elements of the business model to be piloted before moving into full-scale rollout. Figure 18.6 is a snapshot of the canvas, filled in with the final business model proposal defined at the end of this process.

### *Tool 9 – environmental value proposition framework*

The Environmental Value Proposition (EVP) tool consists of a visual (Figure 18.7) containing five process steps, as well as a guiding EVP table developed on the basis of the ReSOLVE framework of the Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2015). With the EVP, companies can design new circular business models or verify intended environmental benefits (Manninen et al., 2018). The core of the framework is the environmental value propositions of the company, which are developed in the first step, and assessed and verified in the subsequent steps together with relevant stakeholders linked to the different life cycle stages of products or services (i.e., the beginning of life [BOL], middle of life [MOL], and end of life [EOL]). The idea of the tool is to follow the five-step process with stakeholders and explore how they can have a role in the joint development of the EVP to create a more positive impact.

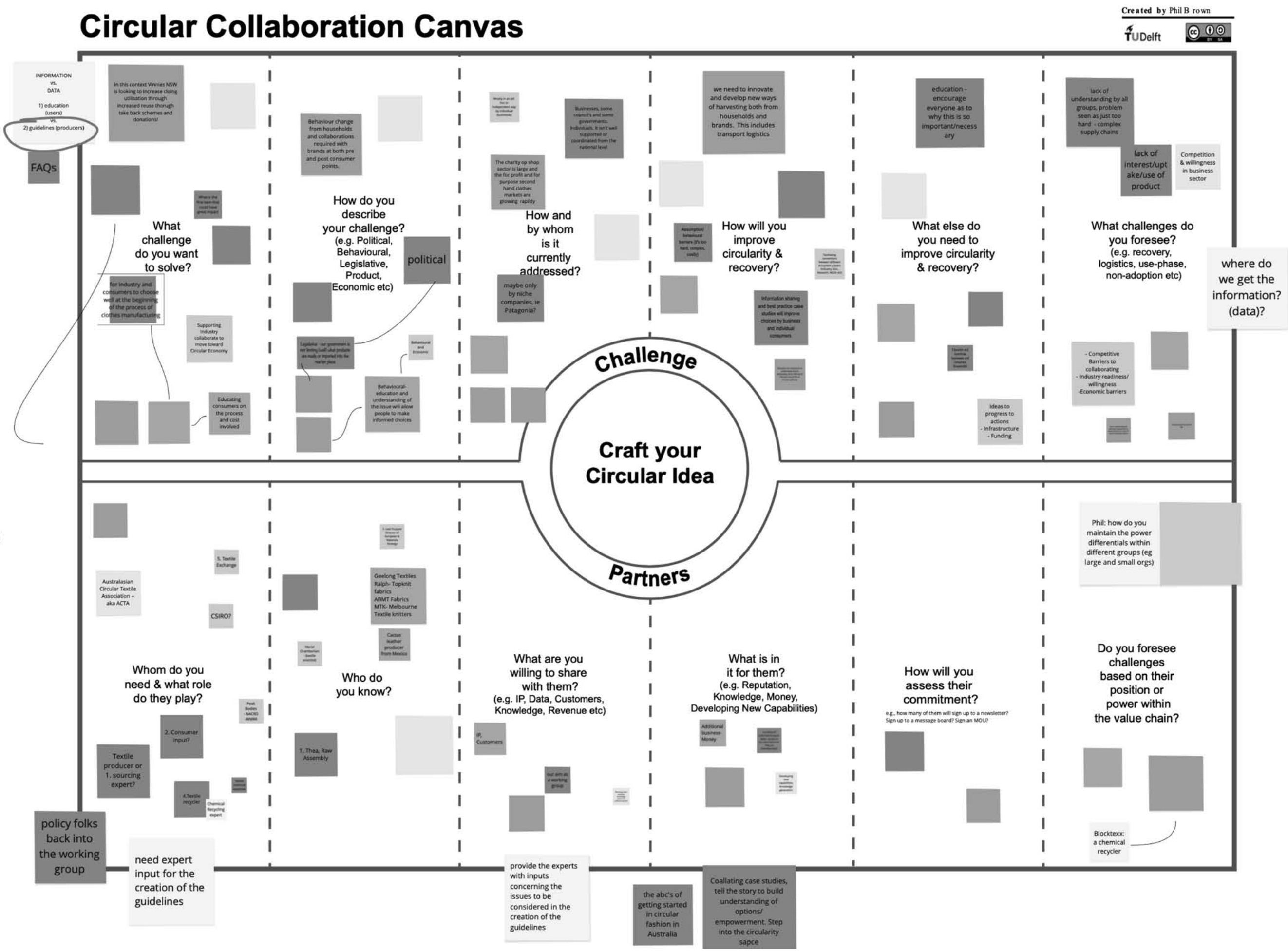



*Figure 18.5* Circular collaboration canvas applied with multiple stakeholders working together to boost circularity in the fashion industry in Australia. For more information, see https://www.monash.edu/circular-fashion/who-we-are.

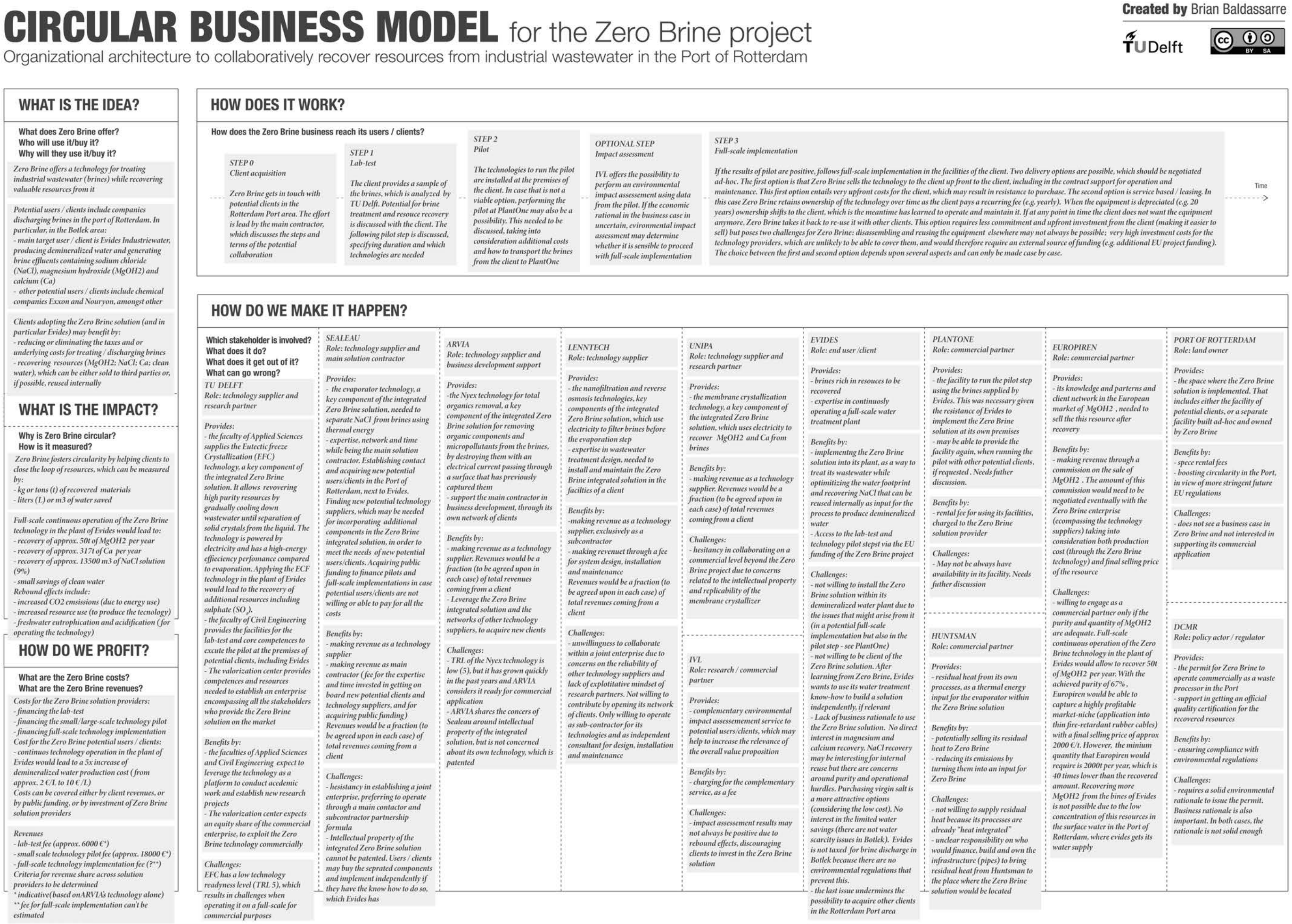



*Figure 18.6* Circular business model pilot canvas applied in the Zero Brine project. For more information, see https://zerobrine.eu.

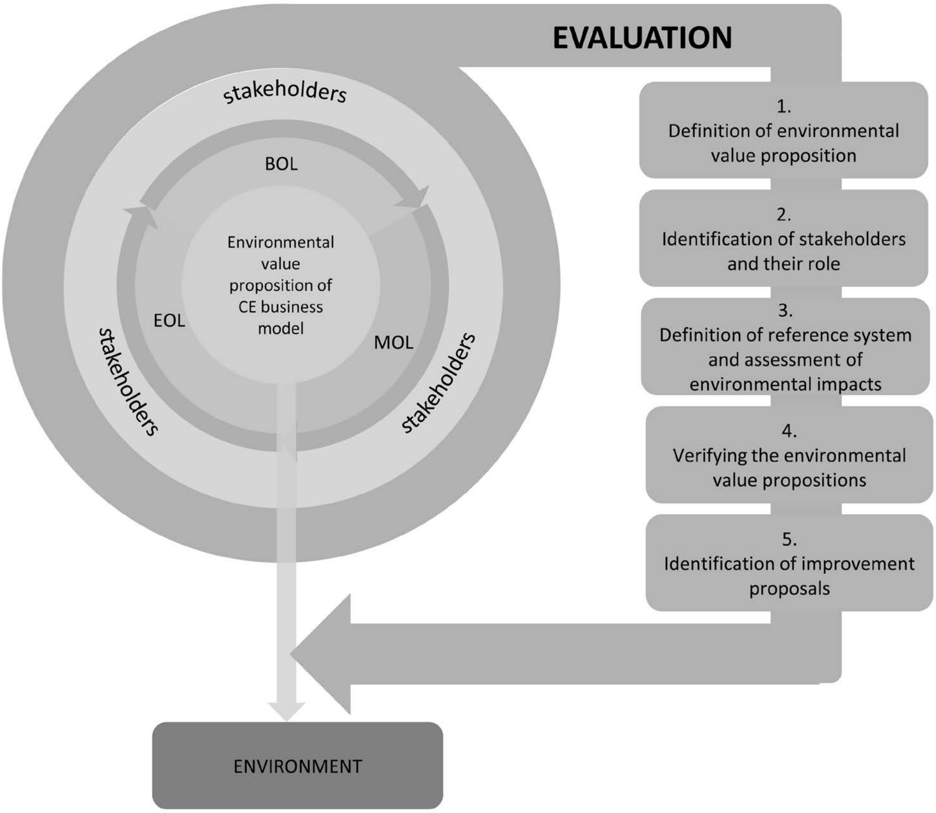



*Figure 18.7* Environmental value proposition canvas.

*Source*: Manninen et al., 2018.

The tool has been applied in a case study on three companies: 1) Deastaclean, a material recycling company producing wood stone, 2) Coreorient, a tool renting company for battery-powered tools and house-cleaning equipment, and 3) Homie, a home appliance renting company. Typically, the process involves ranking the company's environmental priorities based on key environmental impacts, followed by reaching agreement on the main EVPs being targeted by the company. Table 18.2 shows the environmental value propositions for each case. The EVP provides a systemic approach to help companies understand their own activities.

### *Tool 10 – rapid circularity assessment*

The Rapid Circularity Assessment (RCA) aims to assess the environmental impact of new circular business model ideas and concepts (Bocken et al., 2016b). The aim is to help companies consider the most environmentally beneficial options and make changes to the design where feasible. It considers stocks of existing products (e.g., clothing) and new flows (new production of clothing) as well as closing (e.g., recycling), slowing (e.g., longer product life), life cycle impacts (e.g., consumer use), and wider systemic effects (e.g., negative rebound effects) in a visual table (see Table 18.3).

*Table 18.2* Three cases and their environmental value propositions

| *Case-specific environmental value propositions* | *Cases* | | |
|---|---|---|---|
| | *Wood stone* | *Tool renting shed* | *Pay-per-use washing machine* |
| Increasing the life span of wood fibre | X | | |
| Avoiding the use of natural stones | X | | |
| Minimising the use of natural resources through tool sharing | | X | |
| Long-lasting products | | X | |
| Supports travelling without a car | | X | |
| Long-lasting quality washing machines with maintenance contracts | | | X |
| Stimulation of sustainable usage of washing machines | | | X |
| On a longer time scale, the focus on (design for) remanufacturing and refurbishing to prolong the usage of washing machines | | | X |

*Source*: Manninen et al., 2018.

*Table 18.3* Rapid circularity assessment

| | *Flows*<br>*(number of items sold annually by company: influx of NEW products)* | *Stocks*<br>*(number of goods nationally or number of goods per person nationally: products ALREADY IN USE)* |
|---|---|---|
| **Slowing effects**<br>(long-lasting products and extending product life, slowing consumption) | Design to<br>1 extend the useful lifetime of existing or new products<br>2 reduce total new items produced | Design to<br>1 reduce total items in the country<br>2 increase the total number of goods given away for reuse (e.g., secondhand markets)<br>3 reverse overall trends of total goods going to landfill (e.g., by repurposing the materials and increasing recycling rates) |
| **Closing effects**<br>(recycling) | Design for<br>1 increased recyclability of a new product<br>2 increased recycling rates for new goods | Design for<br>1 increased recyclability of existing products<br>2 increased recycling rates for existing goods |
| **Regenerating effects**<br>(cleaner production, renewable inputs, no toxic substances, net-positive strategies) | Design for<br>1 increasing positive impact on the environment, such as increasing biodiversity, for new products and services<br>2 increasing positive impact on society, such as improved education and health, for new products and services | Design for<br>1 increasing positive impact on the environment, such as increasing biodiversity of products and services already in use<br>2 increasing positive impact on society, such as improved education and health of products and services already in use |

(*Continued*)

*Table 18.3* (Continued)

| | *Flows (number of items sold annually by company: influx of NEW products)* | *Stocks (number of goods nationally or number of goods per person nationally: products ALREADY IN USE)* |
|---|---|---|
| **Life cycle effects** (effects across raw material sourcing, production, transport, use and disposal – not yet captured) | Design for<br>1 efficiencies (e.g., less material per product)<br>2 manufacturing efficiencies throughout the production chain<br>3 transport savings<br>4 more efficient or less cleaning<br>5 cleaner forms of recycling<br>6 efficiencies not yet captured | Design for<br>1 transportation savings in the handling of current goods in the country<br>2 increase the total number of goods given away for recycling<br>3 to reverse overall trends of total goods going to landfill (e.g., by repurposing the materials and increasing recycling rates) |
| **System effects** (wider impacts of the innovation) | Key questions to consider:<br>1 Does it lead to negative rebound effects (e.g., consuming more) or positive ones (e.g., from fast to slow fashion)?<br>2 Are there any unintended consequences by upcycling the value of waste?<br>3 Does it lead to radical changes for stores and employees? What are the impacts on those stakeholders and others? Who are the winners/losers?<br>4 What is the effect of multiple coexisting business models?<br>5 What the does this innovation have on society?<br>6 What is required for other companies to follow – is that considered in this new business model? | |

*Source*: Bocken et al., 2016a, 2021b.

The circular strategies on the left column have been used by a clothing company to identify and assess business model ideas to slow and close resource loops (Bocken et al., 2016b). Then, during a workshop with a clothing retailer, the RCA helped to refine ideas and improve the environmental side of the value propositions.

### *Tool 11 – product journey mapping*

In a circular product service system, products naturally change hands. A product will have multiple use cycles. To get people comfortable with transferring and receiving products from and to others, these transitions should be carefully designed. The Product Journey Map is a circular design method that helps organisations preserve and capture the maximum value of a product of the multiple use cycles over its lifetime. Product journey mapping is like customer mapping but with a focus on the product. It is a method for mapping and visualising the life cycle of a product over multiple use cycles (Van Boeijen et al., 2020). Product journey mapping is used in the early stages of development. It helps designers plan a product's journey over consecutive use cycles, identify potential service touch points, and opportunities for capturing value.

Product journey mapping can be useful in the case of, for example, the development of a washing machine lease system with multiple 'use cycles'. In the example in Figure 18.8, the washing machine has three use cycles over its lifetime (premium, economy, and budget). Each use cycle has a different pricing strategy to attract different user groups. For a viable business

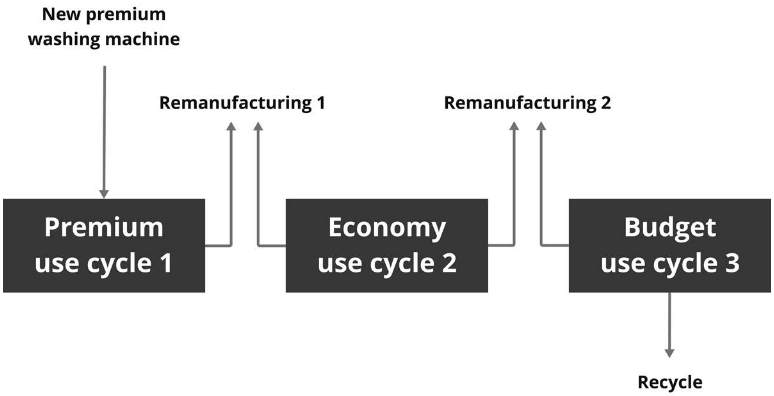



*Figure 18.8* Product journey mapping by mapping the use cycles of the life cycle of a washing machine in a lease system.

case, the same amount of premium, economy, and budget customers are needed. In between each use cycle, the product must be partly remanufactured before the washing machine can go to the next user. In most cases, the rubber gasket must be replaced, which is costly because it is not easy to replace. Product journey mapping can help identify these types of challenges for each use cycle in advance and to plan or develop solutions to overcome them.

### *Tool 12 – value mapping tool*

The value mapping tool (Figure 18.9) is a visual tool and an accompanying process that helps businesses to create value for the company, society, and environment by enabling them to rethink their existing business models. It provides a systematic approach to brainstorm new sustainable business model ideas where negative and positive forms of value creation are explored using a multi-stakeholder perspective. The tool facilitates companies to consider different forms of value (i.e., value captured, value missed, value destroyed, and new value opportunities) and how the company and its stakeholders capture value (positive benefits for stakeholders) or destroy value (negative outcomes of the business) (Bocken et al., 2013). By reflecting on different forms of value for all stakeholders, the tool aims to reduce conflicts and trade-offs among stakeholders and align positive outcomes for all.

Figure 18.10 shows how the visual mapping tool has been applied in a course setting at a higher education institute for the redesign of the business model of a Dutch poultry farm that puts animal health and welfare first and aims to create an environmentally sound business and close cycles by using leftovers from other sources to feed chickens. Design students followed the suggested process steps to use the tool and developed various value creation opportunities for relevant stakeholders and ranked these ideas based on a feasibility-impact matrix to select the most promising ideas for redesigning the business model of the farm.

## Discussion

This study addressed the question: How can design thinking tools catalyse sustainable circular innovation? For this purpose, we developed a unifying framework for design thinking and circular sustainable innovation based on extant literature. Subsequently, we mapped existing design

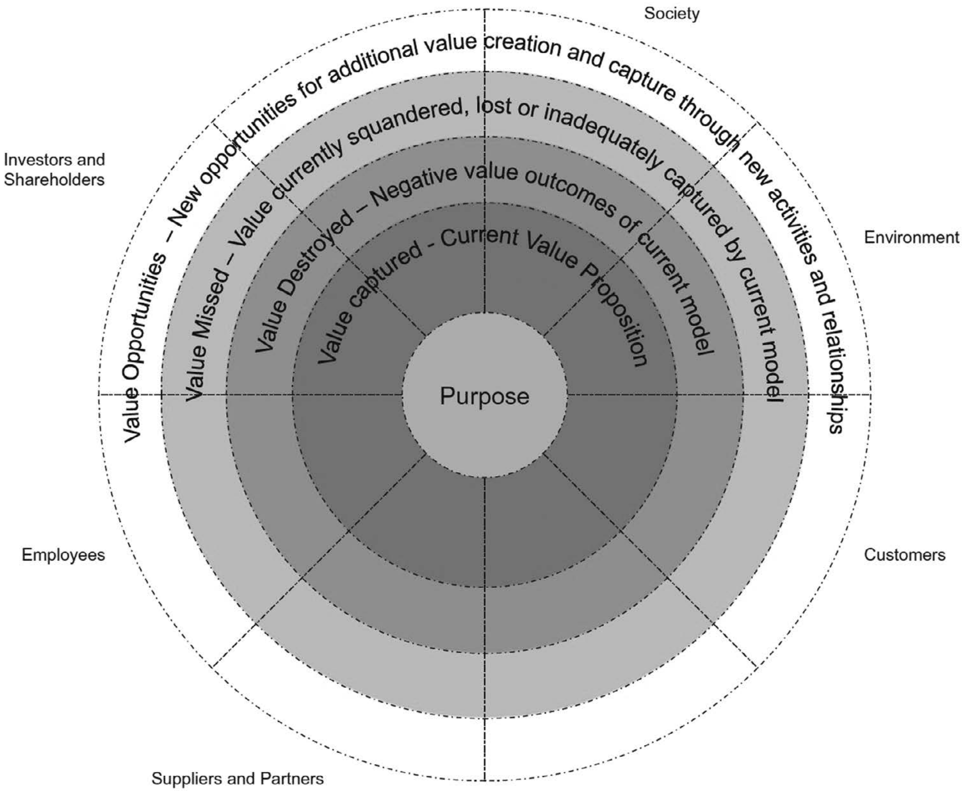
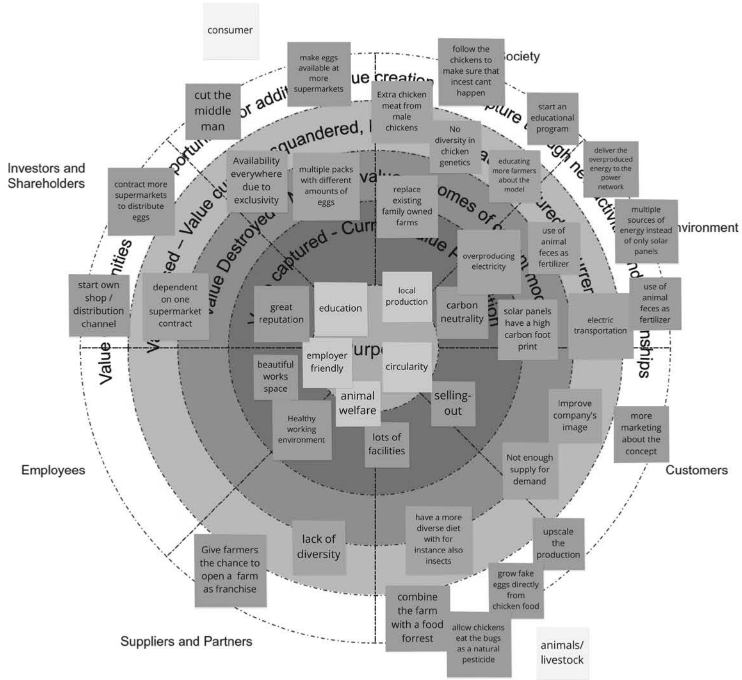



*Figure 18.9* Value mapping tool.

*Source*: Bocken et al., 2013.

thinking tools and illustrated how they have been applied in several sustainable and circular innovation projects. Our goal was to explain how design can catalyse sustainable circular innovation by providing specific tools that can be applied to support and improve processes and outcomes within circular and sustainable innovation projects. In the results section, we presented a list of 'traditional' design thinking tools, and a list of tools created specifically to innovate for sustainability and circularity. For each one of these tools, we provided an illustrative case (Siggelkow, 2001, 2007; Yin, 2011), showing how it has been applied in the context of a circular innovation project.

First, we found that the more traditional design thinking tools such as personas and systems maps allowed for the application of all design thinking principles in varying degrees: systemic thinking, collaboration, future-oriented thinking, within a human-centred and experimental approach to innovation. This is not surprising as these tools emerge from the design discipline, where the design thinking principles build upon by studying the professional practice of designers. This, in turn, shows how design thinking and tools cover the part of the needs of designing for a CE, which is said to require systemic solutions co-created with future customers in mind (Baldassarre et al., 2020b; Bocken et al., 2016a). On the other hand, the CE-specific tools predominantly focus on the principles of systemic thinking, collaboration, and



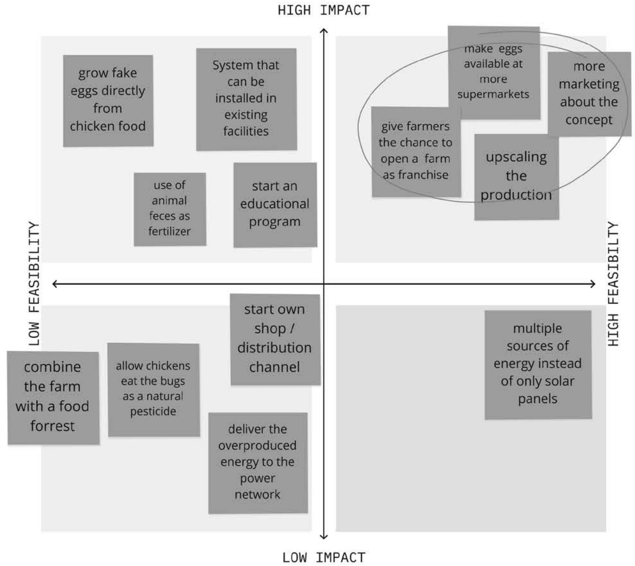




*Figure 18.10* Populated value mapping tool.

experimentation with multiple stakeholders and are to a lesser extent user-centred and future-orientated. CE-specific tools target gaps where current design tools are lacking, but often lack the typical aspects of the original design tools (e.g., being human-centred or focusing on desirability). Hence, it is suggested that both types of tools are still used in conjunction, or that more hybrid integrated tools are used to better encapsulate design-driven and circular aspects. For example, there is a need for the integration of user-centred and futuristic thinking approaches into the CE-specific tools.

Second, with respect to the *success criteria* (i.e., desirability, feasibility, viability, and circularity) we observe that the traditional design thinking tools predominantly build upon desirability and feasibility of new ideas and less on viability (except the business model canvas), or circularity and sustainability, whereas the CE-specific tools build upon feasibility, viability, and circularity criteria. In particular, circularity issues have not been widely integrated into traditional design tools. Hence, traditional tools might lack important aspects such as a focus on the business case and evaluation of environmental impacts, which might hamper the implementation of sustainable and circular innovations, or will not result in increased circularity. A focus on sustainability and circularity is observed in the CE-specific tools we analysed. The CE-specific tools all evidently target the missing circularity and sustainability focus of the traditional design thinking tools. In addition, they cover the organisational aspects to a greater extent with a focus on value creation processes and the viability of product and business ideas.

Third, through our analysis, we observe that two categories of tools differ in terms of their usefulness during the different *phases of the innovation process*. Most of the traditional design-thinking tools are focused on ideation and some on implementation, while few focus on evaluation and continuous improvement. On the other hand, the CE-specific tools cover the phases of innovation process more holistically. In particular, the 'evaluate' and 'improve' phases of the innovation process is crucial for the successful implementation of CE innovations and ensuring their sustainability. In that regard, only a few traditional design tools can be applied in circular innovation projects to deal with complex operational issues (e.g., logistics and changing value chains), multiple life cycles (Rashid et al., 2013; Sumter et al., 2018), and rebound effects (e.g., Castro et al., 2022; Zink & Geyer, 2017). Even though previous studies have hinted at the importance of designers being able to cope with these challenging issues, the gaps in existing tools we identified reinforce the need for better foundations. This highlights the risk of designers continuing to use 'traditional' design tools in isolation when seeking to pursue circular innovations. Some emerging tools start to address issues like rebound effects (e.g., Das et al., 2022). Yet, a greater awareness and education on what circular innovation entails is needed to prepare future designers for circular rather than linear design, as this cannot be captured in single tools and methods.

Fourth, with respect to the different *levels of innovation*, a distinction can be made between the traditional design thinking tools and the CE-specific tools. While more traditional design tools cover predominantly the product and service levels of innovation, the CE-specific tools focus more on the business model and ecosystem levels of innovation. Apparently, this relates to the tools stemming from different streams of research. While traditional design thinking tools are developed based on research in product and service design, the CE-specific tools emerge from organisation and innovation management research, which focuses more on business and collaboration aspects, and require the involvement of a more diverse set of internal and external stakeholders. In that regard, the CE-specific tools appear to cover more diverse aspects of the innovation spectrum, and some tools such as the circularity deck and value mapping are inclusive or flexible enough to cover the different levels of innovation (e.g., product, business model).

*Table 18.4* Focus of design thinking (light grey) and circular (dark grey) tools and methods

| *Circular Design Thinking* | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 Principles** | | | | | **2 Criteria** | | | | **3 Phases** | | | **4 Levels of innovation** | | | |
| Human centred | Future oriented | Holistic, systemic | Collaborative | Experimental | Desirability | Feasibility | Viability | Sustainability, Circularity | Ideate, Design | Implement, Test | Evaluate, Improve | Product / Technology | Business model / Value chain | Ecosystems (e.g., cities) |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

*Source*: Building on Baldassarre et al. (2020b), Brown (2008), Castro et al. (2022), Frankenberger et al. (2013), Guldmann et al. (2019), Rashid et al. (2013), Ries (2011), and Sumter et al. (2018).

The different focuses of traditional design tools and circular tools have been highlighted with light grey and dark grey, respectively, in Table 18.4.

In Table 18.5 we highlight the entire spectrum of circular design thinking principles, criteria, innovation phases, and levels of innovation and skills for circular innovation, aiming to inform the development of future tools that might aid organisations in navigating the circularity transition. Thus, the table provides a novel unifying framework for circular design thinking, based on the literature and cases. The proposed table and framework were developed by combining insights from literature on design thinking and circular innovation with empirical insight and gaps emerging from the illustrations of the tools that we selected. Columns 1, 2, 3, and 4 of Table 18.4, presenting the principles, criteria, and phases, and levels of innovation, are based upon extant literature. In turn, Table 18.5 points to the need for a set of essential skills for circular design thinking: design for multiple use cycles (e.g., durability and remanufacturability); integration of product design with business model (re)design and value chain (re)design; design for sustainable product use (e.g., avoiding rebound effects); and design for material recycling or recovery. These skills are highly interlinked; design for multiple life cycles requires an understanding of business models and value chains because products need to be returned to allow for multiple product life cycles. Moreover, design for sustainable product use to avoid rebounds potentially also requires business model rethinking as it is about consumer behaviour also after the initial 'sale'. Service business models like rental, lease, or pay per use are known to have more touch points with the customer and have been linked to proven sustainability impacts (Bocken et al., 2018; Lindahl et al., 2014). This type of awareness, and the types of knowledge and skills are important for future designers to help them develop more circular and sustainable designs.

We therefore suggest that future tools for circular design thinking should support the use of these important skills. Furthermore, we note that these skills are based on insight and gaps emerging from the empirical illustrations of the tools that we selected. We would like to emphasise that these illustrations are largely related to circular design thinking work conducted by

*Table 18.5* Unifying framework for circular design thinking

| *Circular Design Thinking* | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1 Principles** | | | | | **2 Criteria** | | | | **3 Phases** | | | **4 Levels of innovation** | | | **5 Skills** | | | |
| Human centred | Future oriented | Holistic systemic | Collaborative | Experimental | Desirability | Feasibility | Viability | Sustainability, Circularity | Ideate, Design | Implement, Test | Evaluate, Improve | Product/ Technology | Business model/ value chains | Ecosystems (e.g., cities) | Design for multiple use cycles (e.g., durability and re-manufactur-ability) | Design for integration: product design with business model (re) design and value chain (re)design | Design for sustainable product usage (e.g., avoiding rebound effects) | Design for material recycling or recovery |

*Source*: Building on Baldassarre et al. (2020b), Brown (2008), Castro et al. (2022, Frankenberger et al., (2013), Guldmann et al. (2019), Rashid et al. (2013), Ries (2011), and Sumter et al. (2018).

researchers in the Netherlands. However, we note that important efforts are emerging in other parts of the world as well. For example, the British Design Council recently published a *Beyond Net Zero* report (British Design Council, 2021) developed in collaboration with the Ellen MacArthur Foundation, where circular design thinking and principles are discussed in relation to, among other sustainability paradigms, circularity. Other examples of the emergent focus on circular design thinking projects and tools are provided by the DO school in Germany, the design thinking community in Asia as well as the renowned design consultancy IDEO, which recently developed a circular design guide. We encourage researchers to conduct a more systematic study of these global efforts to expand Table 18.5 with additional insights and gaps underlying circular design thinking skills to be catalysed by future tools.

## Conclusions

In this conclusion section we would like to add some final reflections to pave the way for future research. Around 50 years ago, Victor Papanek urged designers to "design for the real world" by taking full responsibility for the artefacts they put on the market, bearing in mind the resources needed to produce them, as well as all the waste generated after people threw them away (Papanek, 1971). Today, as a new generation of 'circular designers' is more than ever needed to deal with the increasing pressure of these issues, in Europe and all over the world (European Commission, 2022), it is crucial to look behind the tools, to better understand the people who use them. Although ideas on how to use design to address environmental issues are not new and go all the way back to Papanek (Baldassarre et al., 2019a, 2020a), the research field of circular design has been emerging only recently (Van Dam et al., 2020) but building on areas such as eco-design, Design for X (recycling, durability, etc.) and sustainability more broadly (Bocken et al., 2016a; Den Hollander et al., 2017). So far, scholars have explored what circular design is about (e.g., Bocken et al., 2016b), and how it can be practiced through specific skills (Sumter et al., 2018), and through the tools discussed in this study (e.g., Brown et al., 2021; Konietzko et al., 2020). Nevertheless, limited research is available on who these "circular designers" are, and what traits and skills they might possess. Better understanding of who they are, thus their motivation, their challenges, and their personality, is essential if researchers want to create tools that are effective in truly supporting their work. Furthermore, understanding who 'circular designers are' is also important for educational purposes, to ensure that the next generation of circular designers will be equipped with the right tools to deal with the environmental crisis. This type of research is already present in other fields. In the field of sustainable entrepreneurship, for example, scholars have analysed and identified different typologies of sustainable entrepreneurs, distinguishing the social engineer from the social constructionist and the social bricoleur (Zahra et al., 2009). Despite their relevance, similar insights are not yet present in the field of circular design.

The framework in this study provides a starting point for addressing these questions by highlighting circular design thinking skills, as well as gaps in traditional design tools. Accordingly, we encourage future research using the following questions: What characterises the profile of a circular designer in terms of personal motivations and professional challenges? What tools are currently most needed by circular designers? How can the next generation of circular designers be effectively trained? When addressing these questions, there is also another important issue to consider. In circular innovations, users play an active role beyond the traditional notion of 'consumption', becoming circular value creators and deliverers as well. Therefore, next to circular designers, future research should also seek to better understand 'circular users' who may even be the co-creators of novel products and services (consider secondhand or sharing platforms). While insights on who they are and what their motivations are is present, insights on how these relate to the creation of new circular design thinking tools is scant. We also encourage future research in this direction. Finally, we note that focusing on circular designers alone might not be sufficient, because in circular innovation, users play an active role as circular value creators and deliverers. This will open new areas for circular design and innovation research and practice.

## Educational content

- This chapter proposes principles, criteria, phases, and levels related to sustainable circular innovation through a design thinking approach.
- Skills for circular innovators are outlined, including design for multiple life cycles, design for integration, design for sustainable product use, and design for material recycling or recovery.
- Future research might go beyond these skills to better understand the professional profile of 'circular designer' in a more thorough and holistic way.
- Education may leverage these insights in order to further develop and nurture the skills of innovators capable to deal with the challenges of the current and aggravating environmental crisis.
- The design thinking tools proposed in this chapter may provide a starting point for teaching circular innovation to students in design, architecture, engineering, and management schools.

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