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Cards for circularity: Towards circular design in practice

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Abstract. The transition towards a Circular Economy (CE) in the built environment is crucial to achieve the Sustainable Development Goals (SDGs). Theoretical frameworks and methods for circular design have been developed. Yet, there is a lack of knowledge on circular design in practice and how circular design thinking can be supported. This study aims to provide insights on circular design in practice and how this can be supported through circular design methods. First, we reviewed existing circular design methods and developed a card-based circular design tool. Next, an interactive survey and design workshop using the tool was carried out with 12 design experts to gather knowledge on circular design in practice. Finally, we derive key learnings that can support the development of circular design methods and advancement of CE in practice. Overall, circular design remains highly conceptual and is challenging due to the interconnectedness of parameters and temporal aspects such as product life cycle. Designers need ways of educating and convincing stakeholders on the value and feasibility of circular design. Advancing the CE in practice requires circular design methods that help to contextualize the design process and reduce complexity, and examples are needed of how CE can be implemented in practice.

1. Introduction

To realize the Sustainable Development Goals (SDGs) proposed by the United Nations such as SDG 12 (Responsible Consumption and Production), it is vital to move away from the current linear economy that follows a take-make-use-dispose principle, towards a Circular Economy (CE) [1]. In a CE, economic growth is decoupled from resource consumption and the notion of waste is eliminated by keeping products, components and materials at their highest utility and value [2]. There is a wide consensus among academics and the industry that designers play a pivotal role in realizing a CE and some consider them as catalysts for the CE transition [3,4].

Designing for a CE requires fundamentally different design strategies and methods that support a holistic and systems approach to problem solving and concurrent development of a circular design, supply chain and business model. Furthermore, designers need to consider temporal aspects such as technical product lifetime and the length of use cycles [5]. Previous research has defined frameworks, methods and strategies for circular design and investigated the changing roles, competences and skills of designers in a CE [3–9]. However, the studies often remain conceptual and theoretical. Little research has been done on circular design in practice and how circular design thinking can be supported, implemented and shared through the use of circular design methods.

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Therefore, this paper aims to generate knowledge on how design practitioners relate to and implement circular design in practice and how implementation can be supported through circular design methods. The research is conducted in three steps. First, we reviewed existing circular design methods and developed a card-based circular design tool. Second, we conducted an interactive survey with design practitioners to evaluate current knowledge and practices regarding circular design. Following, in a workshop, participants developed circular design concepts using the developed design tool. Third, we reflect on the findings and derive key learnings on circular design practice and how it can be supported.

2. Development of a card-based circular design tool

Many methods, tools and frameworks have been conceived to support circular design. These originate from academics (e.g. [10,11]), and several tools have been introduced in practice or grey literature [12]. Based on a systematic literature review and analysis of 36 existing circular design frameworks, Van Stijn and Gruis [13] developed a design tool for circular building components: The circular building components (CBC) generator. This tool presents all relevant design parameters which should be considered (e.g. materials, lifecycle, circular design strategy, type of financial arrangement); it provides extensive design options per parameter and it supports a systematic synthesis to an integral and cohesive circular design. Although other tools could also support circular design in practice, their tool was found to be the most comprehensive and was developed specifically for use in the built environment. Therefore, it was adopted as the theoretical foundation for the circular design tool used in this research. However, despite the comprehensiveness, it is most of all a theoretical tool and in its current state not optimal for use in a workshop setting.

Hence, a card-based circular design tool was developed: Cards for Circularity (CfC). The card-based format was chosen as it is discussed in literature as beneficial for ideation processes in design practice: a key strength is that they provide summarized, semi-structured information bridging the gap between unstructured tools without content, like post-it notes and detailed, structured information like instruction manuals [14]. The CfC tool consists out of a wide variety of cards. Each card provides a circular design option for a specific circular design (sub) parameter. Design parameters relate to choices designers need to make in a circular design, e.g. which *circular design strategy* is applied, which *materials* are used and what *cycles* a product makes. There are three colors of cards, distinguishing the technical model (the physical design of e.g. a product or building), the industrial model (supply chain management) and the business model (marketing and finance). See Figure 1 for an exemplary card from the technical model. The tool can be used in different contexts and phases of the design process, from ideation to conceptualization.

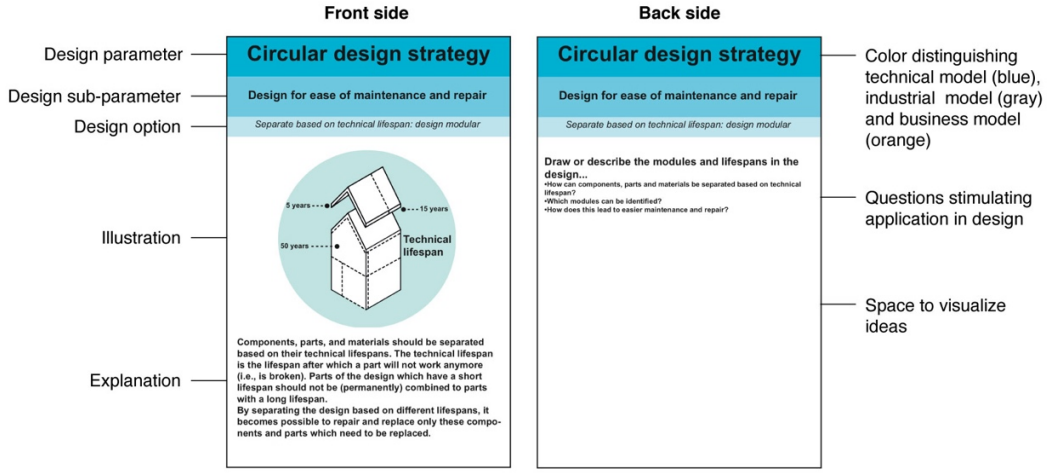

Figure 1. An example of a card for the design parameter 'Circular design strategy' and sub-parameter 'Design for ease of maintenance and repair'

3. Methods

During a half day workshop (approximately 5 hours), a design workshop was carried out with 12 design experts (10 practitioners and 2 researchers) to gather knowledge about circular design in practice, to evaluate the CfC's potential to support a circular design process, and to reflect on the knowledge gained from the workshop.

3.1. Interactive survey with designers

An interactive survey with the participants was carried out prior to the design workshop, to evaluate their knowledge, experiences and practices regarding circular design. The participants were invited to partake in a lunch that was collaboratively prepared in order to get familiar with each other and promote interaction. The aim of the survey was, aside from gaining insights about circular design in practice, to find challenges in practice that could potentially be addressed through the card-based tool. An interactive polling tool (Mentimeter) was used to ask a range of questions to the participants. The questions focused on knowledge and practices regarding CE and challenges regarding CE for designers and businesses. After each question time was given to the participants to verbally highlight further thoughts and engage in a group discussion.

3.2. Workshop using the Cards for Circularity

After the interactive survey, the participants were divided in three groups to continue with the design workshop. The cards were shortly introduced, and an assignment was given to each group. The assignment took around 45 minutes and was meant to be explorative. Thus, it was quite broadly defined, namely to design ideas and concepts for circular kitchen furniture and appliances using the CfC. A reduced pack of cards was provided (48 cards) representing design options for the following parameters – material, lifespan, lifecycles and circular design strategies. These were all parameters of the technical model. Options for the business and industrial model were excluded from the assignment due to the scope and limited time for the workshop. Each group was invited to a table, where the cards were laid out on a map that showed the different categories to provide better structure and a way of navigating. Each group had the same cards, but to provide a different context, they had to focus either on kitchens for rental or privately-owned apartments, which might have an influence on how the groups would discuss demands of the user.

3.3. Data collection and analysis

Data was collected in the form of survey responses, audio records, written notes and observations. The audio recordings were transcribed and analyzed by using the software NVivo 12. Through emergent coding a list of first-order codes was generated. Next, we searched for relationships between the first-order codes to assemble them into second-order codes relating to attitudes, challenges and enablers for circular design in practice.

Figure 2. Overview of the map with the cards (left) and the cards in use by one of the groups (right)

4. Findings

4.1. Findings from the survey and group discussion

The interactive survey and group discussion revealed insights into the participants understanding of the CE, and how CE principles are considered and implemented in practice. All 12 participants were familiar with the CE concept, and 3 participants stated to have worked with it concretely in practice. The participants considered 'setting up collaborations and aligning stakeholders' and 'finding sustainable business models' as the two biggest challenges when designing for a CE. Furthermore, for businesses to embrace the CE, 'a lack of practical knowledge' and the fact that it 'doesn't fit the current capabilities and business models' were pointed out as the two biggest challenges. These two challenges were further emphasized in the group discussion that followed the survey. One of the participants mentioned that companies get overwhelmed once they understand the complexity of the CE and the changes it might require to the business model. As a consequence, this might then lead to smaller changes or 'greenwashing' instead. Often, there is a different understanding and definition between designers and clients of what CE implies in practice. According to another participant who works for a design consultancy, it's difficult to get circularity on the agenda and in design briefs, and mentioned that:

> "A lot of companies they don't realize what kind of big change they stand in front of … of course you can start with just changing the materials to take this small step, baby steps, but I think that's just a very, very small way to make progress."

Some participants mentioned that it feels like designers have to 'sell' sustainability and circularity to companies, and that it is important that designers take on the role of educating and convincing companies and people about CE. Yet, this role is considered as challenging due to time limitations in projects and a lack of successful practical examples to convince clients of the value and feasibility of a circular design and business model. One participant highlighted:

> "There's also an importance of making more people understand what a circular economy is about. Because right now it's like a buzzword. Companies and people are talking about it, but they don't really know what it's about. And they do not know what they can do to make progress."

Designing for a CE is generally considered as challenging by the participants. It is difficult to maintain a holistic perspective as each design decision affects another. Moreover, it is hard to predict the consequences of decisions such as the selection of materials. One participant highlighted that there is a lack of involvement and control once products are on the market. This designer illustrated through an example that despite considering the 'end-of-life' scenario in the design of a product, there was no system in place to take care of the products and materials as intended:

> "They smash the whole car, they don't separate everything. So, the way we've been working, trying to create seats you can separate, and instrument panels, that's not the way they do. They just eat the whole thing and then different machines shake the different plastic parts."

Furthermore, to advance the transition to a CE, several aspects related to circular design were highlighted. Designers need to be well informed about business models, material alternatives and end-of-life scenario's when proposing solutions. There is a need for more transparency, connection and collaboration with local stakeholders such as users, material and business model experts and recycling facilities. The locality here was considered important, as recycling practices for instance might be different depending on the place or infrastructure. Lastly, several participants highlighted the importance of finding ways to convince clients and other stakeholders about circularity. For example, an 'idea bank with good practical examples' as mentioned by one of the participants, could help to inspire and broaden perspectives, and show what is possible to realize when it comes to circularity.

4.2. Results from the design workshop

This section elaborates further on the results of the design workshop in which three groups used the card-based tool to develop concepts for circular kitchen furniture and appliances. Figure 3 presents an overview of the cards that each group used in the process, and specific ideas that were generated.

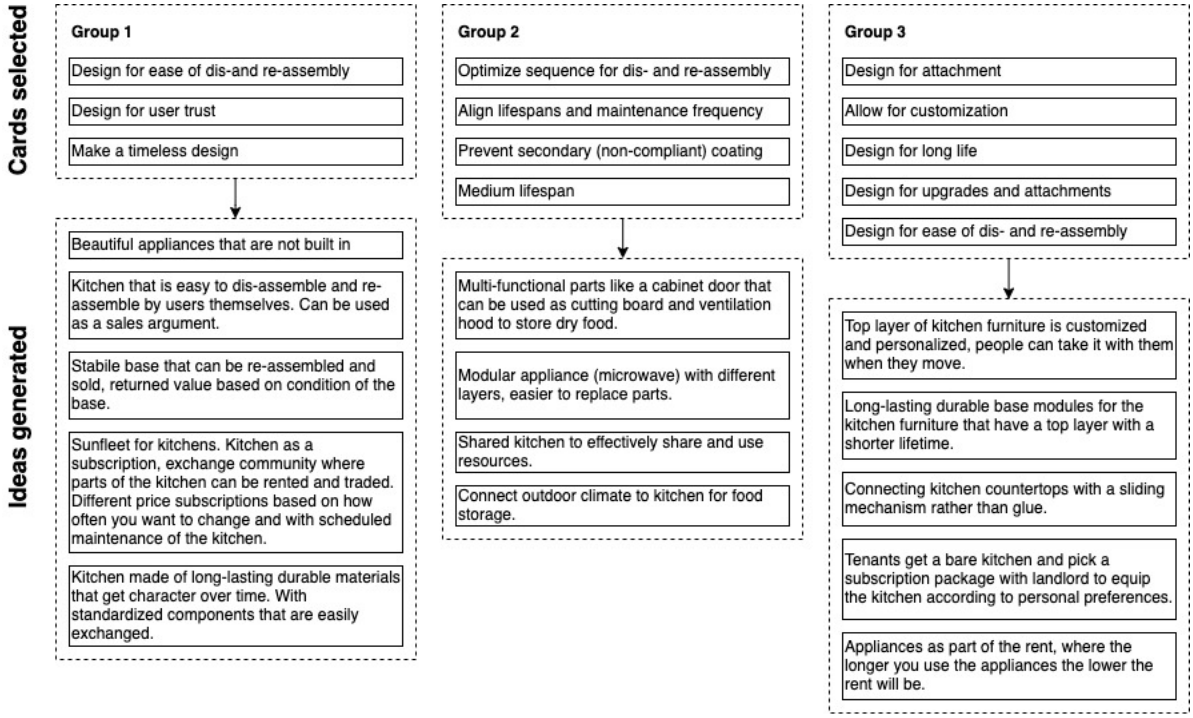

Figure 3. Overview of cards selected by each group and generated ideas

The groups managed to consider not only the technical design and the user context, but also time-related aspects such as lifespan and use cycles. Furthermore, group 1 and 3 made considerations about business models and came up with ideas for a service around their design. Group 1 and 3 also used the cards for immediate evaluation, to find agreement and verify that an idea followed the principles of a certain circular design strategy. Some ideas generated by the groups specifically showed considerations of systems thinking, lifespan, supply chain and business-model, that are essential to enable a circular design (see Figure 4).

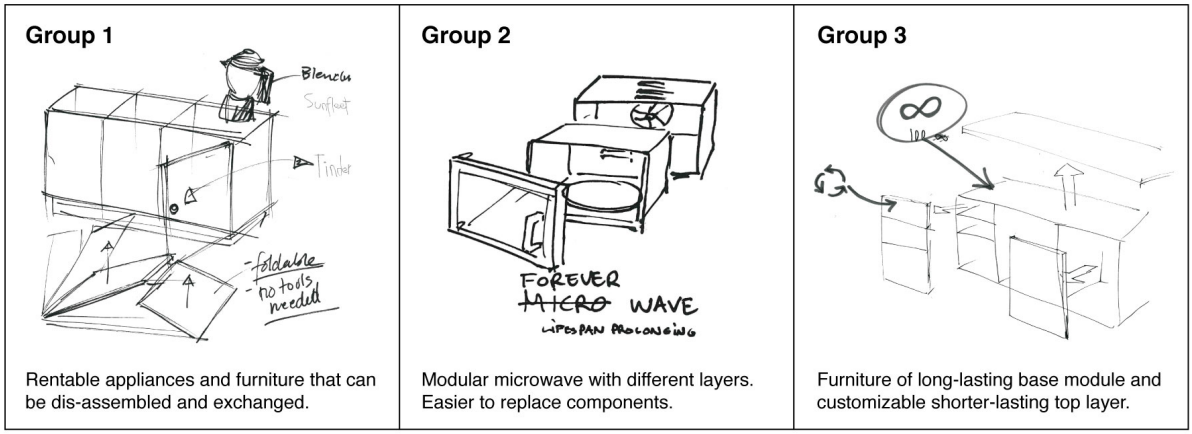

Figure 4. Selection of sketches that show circular design thinking by the different groups

Group 1 came up with the idea of having rentable appliances and kitchen furniture as a service. This service could be connected to an online community where parts of the kitchen can be traded and exchanged, like the exterior fronts of the kitchen furniture and the appliances. The furniture would

consist of a durable base that maintains value over time, and can be dis- and re-assembled as well as redistributed to other users. Group 2 generated an idea for a modular appliance (a microwave). It consists of different layers where it is easier to replace components that tend to break, such as the front door. Group 3 developed an idea for rental apartments, where people might live a shorter time but would like to personalize the kitchen according to individual demands. This resulted in an idea for kitchen furniture, where the top layer of the furniture is 'customized' and detachable: tenants can take this layer with them when they move, making the kitchen more personalized. Durability was discussed next: the base could be made out of a durable material and last 100 years whilst the top layer could last less long. Hence, a less durable material could be applied.

4.3. Findings from the design workshop

The participants appreciated how the cards helped guide the discussion and supported idea generation and creativity within the scope of circularity. Yet, the results from both the interactive survey and the workshop indicate that circular design is challenging for the participants due to the complexity of parameters and choices. The groups struggled with the overwhelming number of cards and parameters and found it difficult to make choices, which obstructed the overall ideation process. The cards were appreciated and showed to be a structured and actionable way to present information. However, the way the cards were laid out on the map added complexity and did not promote a random selection of cards. Additionally, the groups had difficulty with the time-related cards and considering and distinguishing time-related aspects such as lifespan and lifecycle. A particular challenge and question that emerged during the workshop was 'when is a design circular?'. One participant mentioned that although their group had made a design for a modular kitchen, it did not automatically make it a circular design. Another participant stated after the workshop that it requires material experts and contextual knowledge of products and materials to make estimations on the lifespan of a design and how long parts last. Nevertheless, the cards supported groups with different perspectives and levels of understanding of CE to discuss strategies and definitions, find consensus and translate the information to concrete ideas.

5. Key learnings on supporting circular design in practice using circular design methods

From the findings we derived key learnings on circular design in practice and how it can be supported using circular design methods (see Table 1).

The findings from the interactive survey with design practitioners indicate that their clients often show a lack of willingness to commit to a circular design, due to the complexity and changes it might require to their current business model. Non-technical challenges, like the lack of willingness to engage with CE, have been highlighted as one of the main barriers for a CE [15]. Furthermore, there seems to be a wide range of different definitions and understanding of CE, which obstructs agreeing on uniform approaches. This has also been discussed by various scholars (e.g. [16]). The participants point out the importance of educating and convincing companies and people about the value and feasibility of a CE, but lack time and successful practical examples to do so. Designers might have the potential to catalyze the transition to a CE [17], but they have to be supported with circular design methods that not only help to overcome technical barriers, but also non-technical barriers such as hesitant company cultures, different understanding and definitions of CE, and limited willingness to engage and collaborate for achieving a CE. The results from the survey and workshop indicated that designing for a CE is challenging due to the complexity and interconnectedness of design choices, and time-related aspects such as lifecycles and lifespan. Circular design methods should aim to structure and contextualize the design process, support focusing on specific challenges while keeping a holistic perspective.

The participants in this study asked for more knowledge on business models, material alternatives and end-of-life scenarios. It is likely that designers have to develop more proficiency in these fields, which has been highlighted in previous research [5,9]. However, the participants also stressed the importance of collaboration with local stakeholders and knowledgeable experts. It seems vital to find ways that enable collaboration and co-creation early in the design process and throughout the lifecycle of products, buildings and services.

Table 1. Summary of key learnings and how design methods can support circular design in practice.

Nr.	Key learnings regarding circular design	How it can be supported through circular design methods
1	Clients lack willingness to engage with circular design.	Tools and aids that help educate and convince stakeholders on value and feasibility of circular design and business models.
2	Circular design is regarded as highly conceptual and theoretical. Lack of information on how CE can be implemented in practice.	Include practical examples (e.g. idea bank) of circular design that inspire, broaden perspectives, and help convey the feasibility of a CE.
3	Circular design is challenging due to complexity of parameters and lifecycle thinking, this obstructs the ideation process.	Reduce the complexity by contextualizing the design process. Enable focus on specific challenges while keeping a holistic perspective, this can also lower barriers for idea generation. Provide information about business models, material alternatives and lifecycle considerations.
4	Different CE definitions and understanding and a lack of collaboration with local stakeholders and knowledgeable experts in design processes.	Tools that align definitions/understanding and establish/support collaboration with stakeholders throughout design process and lifecycle of products.

6. Discussion and conclusion

The aim of this paper was to generate knowledge on how design practitioners relate to and implement circular design in practice and how this can be supported through circular design methods. The key learnings as presented in section 5, could provide useful input for the development of circular design methods. These methods can, subsequently, help overcome barriers experienced by design practitioners and contribute to the implementation of CE principles in design practice.

However, some limitations should be noted. This study was intended to be explorative and therefore does not include a statistically relevant sample size. All participants had design experience and prior knowledge of CE. Furthermore, all groups made use of the same set of cards during one workshop and no control groups were included. Therefore, no connection can be made between the CfC, the perceived usefulness and the quality of the design suggestions. However, the findings indicate that the cards helped to spark ideas, guide discussions and kept the focus on specific challenges related to circularity.

Further research could focus on collecting more evidence on circular design in practice, e.g. through studying successful cases and testing of other tools. This could help validate the findings in this research and advance the development of circular design methods. The CfC will be further developed by evaluating the usefulness of the cards in multiple case studies and in co-creative processes with multiple disciplines and stakeholders. The cards showed potential not only as a generative tool, but as a way of staging discussions on definitions and strategies regarding circularity and align perspectives in a multi-disciplinary context.

In this study we generated insights on how design practitioners relate to and implement circular design in practice, and how implementation can be supported through circular design methods. The participants of this study indicated that there often is a mismatch in willingness towards circularity between designers and clients. Furthermore, there seems to be a wide range of different definitions and understanding of CE, which obstructs agreeing on uniform approaches. Overall, for the workshop participants, circular design remains conceptual and theoretical. There is a lack of examples for designers on how CE can be implemented in practice, and unclarity on the impact they can have on the implementation. In addition, circular design is considered a complex challenge due to the interconnectedness of choices/parameters and time-related aspects such as lifecycles and lifespan.

From our findings we derived key learnings about circular design in practice and how these can be supported. We highlight that circular design methods should help overcome technical but also non-technical barriers, such as educating and convincing stakeholders on the value and feasibility of circular design and business models. Practical examples on how CE can be implemented could help designers convey the feasibility of a CE and convince clients to commit to a coherent plan towards circularity. Furthermore, circular design methods should reduce the complexity and contextualize the design process. Finally, aligning definitions on CE and collaborating with relevant stakeholders and knowledgeable experts during and after the design process seems vital to enable successful circular design solutions in practice.

Realizing CE practices and establishing a closed loop of products and material flows, will be necessary in achieving the SDGs, such as e.g. SDG 12 (Responsible Consumption and Production). The role of design seems vital in advancing the transition to a CE, but this role requires circular design methods that help overcome the technical, as well as the non-technical barriers that are currently hindering practical implementation. Without fundamentally changing the way we design buildings, products and services the potential of a circular economy might not be achieved. Through this study, we hope to contribute to the advancement of circular design in practice.

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