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TOWARDS FOSTERING CIRCULAR MINDSETS IN MAKER SPACES

Michael DEININGER[1] **and Therese BALSLEV**[2]
[1]Technical University of Denmark, Denmark
[2]Danish Design Centre, Denmark

ABSTRACT
To support the distribution of a circular economy design framework to makers in Makerspaces and Fab Labs, this study compared two methods: a facilitated workshop and a self-guided journal. The research aimed to test whether a traditional in-person workshop is more effective than a self-guided journal for fostering circular mindsets among makers.
The Circular Strategies Wheel, a tool developed by Danish Design Centre, was used as the basis for both methods. The Circular Strategies Wheel presents makers with 18 circular strategies across three product lifecycle stages of products and materials. The circular strategies and lifecycle stages were shared through a workshop that consisted of a facilitated, two-hour session and included an introduction to circular economy concepts, followed by a guided mapping exercise. The journal consisted of a 26-page self-guided workbook that contained the same introduction to circular economy concepts and strategies and included reflection prompts and links to additional resources.
Participants were recruited through various channels and completed survey questionnaires before and after participating in one of the two intervention methods. The results showed that both methods supported the development of circular mindsets, but with some differences. The workshop revealed a statistically significant increase in self-assessed knowledge ($p<0.0001$), and significantly higher confidence levels for applying circular economy principles ($p=0.0046$). The journal also showed knowledge increases, but they were not statistically significant ($p=0.535$).
These findings suggest that while guided workshops require skilled facilitators and preparation, they more effectively build knowledge and confidence among participants. Self-guided journals offer scalability advantages but may need improvements to match workshop effectiveness. The study was limited by small sample sizes, unequal group distributions, and varying age ranges between the two groups.

Keywords: Circular economy, design mindsets, design methods, distributed design, fab labs, makerspaces, strategic design, design thinking, circular product development

1 INTRODUCTION
Widely distributing design methods can be challenging and is often limited by the form of distribution. In this study, two methods of distributing a design method aiming to develop circular mindsets among makers in Makerspaces and Fab Labs were compared. A maker could describe anyone: cooks preparing food, gardeners tending plants, or knitters crafting clothes. Fab Labs and Makerspaces are small-scale workshop areas offering, for example, digital fabrication and (rapid) prototyping support to anyone interested. The maker movement has emerged from people's desire to be more than just consumers and instead participate in the creation of objects, thereby contributing to the democratisation of design and innovation. New levels of interconnectedness enable information sharing and support today's maker movement that is built on former micro-communities that were defined by a particular hobby or activity [1]. The heterogeneous culture generated by these makerspaces continues to play an essential role in stimulating innovation and expanding the impact of the maker movement [2].
Distributed Design as a framework emerged at the intersection of the Maker Movement and design sensibility, targeting designers, creatives, and makers. Distributed Design aims to enable a more sustainable, open, democratic, inclusive, and community-based way of producing, making, and designing physical as well as non-physical products [3]. In the face of potential global challenges like pandemics, wars, declining biodiversity, climate crisis, etc., Distributed Design can be considered an

active response towards increased resilience to supply chains concerns while offering a more sustainable way to designing, making, and producing.
Circular Economy (CE) is a concept based on the principle of decoupling value creation from resource consumption. Instead of a linear mindset, where value creation is based on the 'take-make-use-dispose' dogma, CE focuses on continually extracting value from resources for as long as possible by extending the useful lifetime of products and materials [4].
For makers to have a positive impact on the environment and increase the circularity of products, proper information, tools, and methods are needed to inform their decisions [5]. Equipped this way, makers can become change agents for a Circular Economy mindset and facilitate the necessary transformations in human interactions and relationships [6]. A common way for distributing design methods and tools is through workshops that are often led by a facilitator. Another effective tool to distribute knowledge and support learning is reflective practice, where participants reflect on their actions either while they are performing them (reflection-in-action) or afterwards (reflection-on-action) [7].
The Circular Strategies Wheel forms the basis for this study [8]. This framework was developed in collaboration with Danish Design Centre (DDC) and is inspired by the work of Blomsma et al. [9], Potting et al. [10] and DDC [11]. This framework is divided into the three lifecycle stages of products and materials: 1) Start of Life, 2) Product Life, 3) End of Life. Each stage contains specific circular strategies relevant to each of the three phases to be considered during product development, business model generation, etc. Specifically, they are: Design, Raw Materials & Sourcing, Manufacturing, Distribution, Care, Upgrade, Reuse, Repair & Maintenance, Refurbish, Remanufacture, Repurpose, Upcycle, Resell, Collection & Sorting, Disassembly, Recycle, Cascade, and Recover (Figure1).

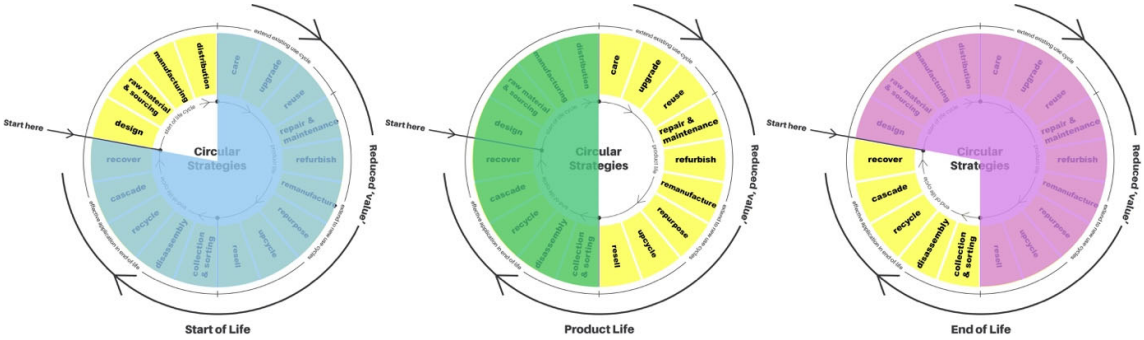

Figure 1. The three lifecycle stages of products: Start of Life, Product Life, End of Life

In both the workshop and the self-guided journal method, participants applied the tool by carrying out a mapping exercise to identify how their project might relate to the 18 circular strategies presented in the framework.

2 RESEARCH OBJECTIVE

To help identify a less labour-intensive format that supports a wide distribution of the Circular Strategies Wheel among makers, this study investigated a self-guided journal as an alternative to the facilitator driven workshop by testing the following hypothesis: *A traditional in-person workshop is more effective than a self-guided journal in distributing a design framework and fostering a circular mindset in makers.*

3 METHODS

Two methods for distributing CE knowledge were used in this study: A) a facilitated workshop, and B) a self-guided journal (Figure 2).

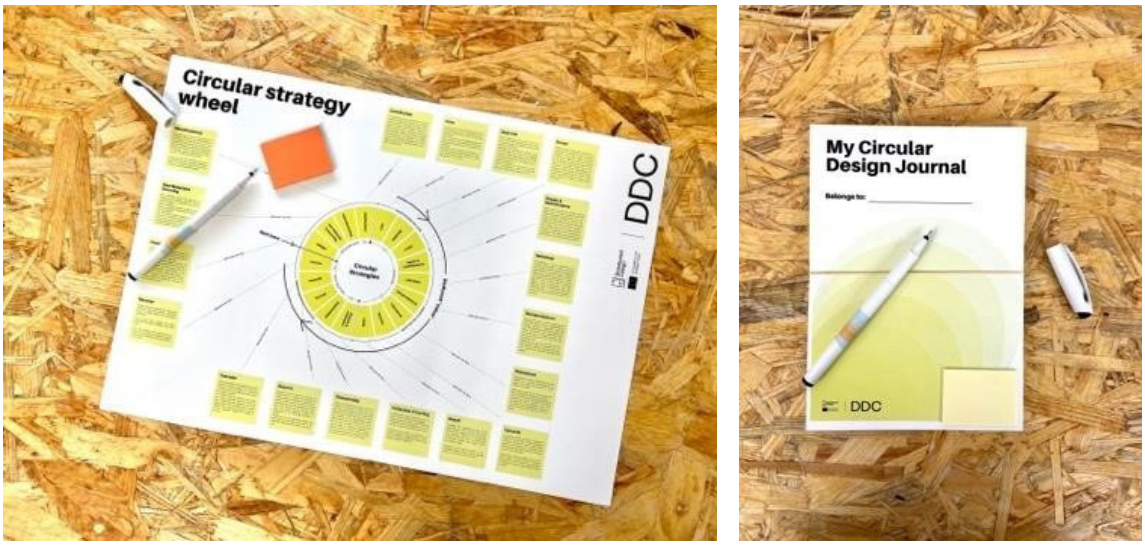

Figure 2. Circular Strategy Wheel used in the facilitated workshop and the self-guided Circular Design Journal

Method A was set up as a two-hour workshop with a short introduction to CE, the different CE strategies, and some examples of applied CE strategies. The participants received an introduction to the exercise with the facilitator explaining each step. Afterwards the participants were given approximately 50 minutes to carry out an individual mapping exercise. The facilitator was available to answer questions.
Method B was set up as an individual journal exercise inspired by elements of Schön's reflective practice theory [7]. The journal given to the participants consisted of 26 pages and introduced the participants to CE, the different CE strategies, and the CE framework. The journal contained a dedicated page for each of the CE strategies and invited participants to reflect upon opportunities for their project and their motivation to work in the field of circularity. On each page, a description of the strategy was provided, and participants were encouraged to write down their thoughts, ideas and obstacles related to the specific strategy. An example of the encouragement related to the circular strategy 'Upgrade' was: *"How have you considered upgrading in your project? You can note what you have already implemented, opportunities, what to explore further, as well as obstacles."*
The CE strategy pages in the journal also contained a QR code directing the participant to a webpage of relevant research where they could find more in-depth information about each strategy. Participants were given up to eight weeks to complete the journal of their project and associated learning journey.
Participants in this study were recruited through social media, websites, newsletters, email lists, and physical postings in Makerspaces and Fab Labs in Denmark and Austria. All participants were informed of the purpose of the study, agreed to participate, were ensured of their anonymity, and were made aware that they could withdraw at any time. No compensation was provided. To increase the number of participants, both concepts were offered in physical and virtual format to allow remote participation. Physical workshops were carried out in a Fab Lab in Vienna, Austria. The online workshops were conducted via Zoom and used Miro to support the Circular Strategy Wheel exercise.
To evaluate the two concepts, a survey questionnaire (SQ) containing both close- and open-ended questions was given to participants both before they started and after they finished participating in one of the interventions. Only participants who answered both SQs were included in the analysis.

Table 1. Participants in the two intervention methods

Intervention	Code	Signups	Participants	SQ1 Respondents	SQ2 Respondents
A - workshop (physical)	A1	16	9	9	8
A - workshop (online)	A2	250	80+	65	37
A - workshop (online)	A3	N/A	20+	21	13
		266+	**109+**	**95**	**58**
B – journal (physical)	B1	18	N/A	18	9

B – journal (online)	B2	40	N/A	16	5
		58	**N/A**	**34**	**14**

Table 2. Distribution of age and gender identification

Intervention	Number of participants (n)	Gender identification	Average age
Workshop accumulated A1, A2, A3	58	55.2% female 43.1% male 1.7% other	32.42 years
Journal accumulated B1, B2	14	50% female 41.7% male 8.3% other	42.04 years

To evaluate how interventions A and B contributed to an increased level of knowledge about CE among the participants, a tool for coding answers to the open-ended questions was developed. The responses from the participants were carefully read and categorised by the research team according to the assessment criteria shown in Table 3.

Table 3. Criteria for assessment of knowledge on circular economy

Category	Level of knowledge	Description	Example
I	None to very limited, or no answer	None - no or very little knowledge. Participant does not mention any keywords related to the topic or leaves no comment.	"None. But I have a passion for sustainability."
II	Low or limited	Participant might indicate that they know about the overall concept but do not mention any concrete keywords related to CE.	"Try to reduce the use of materials in a design process as much as possible."
III	Medium	Mentions some fundamental aspects of CE by also including different circular strategies/concepts e.g., "repair", "durability", "recycling", "no waste" etc.	"As the name specifies, it is about creating a life cycle in our economy, not wasting or destroying things that can be reused and, in that way, promote sustainability."
IV	High to advanced	Mentions more fundamental aspects and strategies linked to CE - e.g., the different design strategies like "reduce", "repair", "reuse", and more advanced concepts/principles like "design out waste", "upstream innovation", "regeneration", etc. Might also mention how CE is linked to business models and the systemic changes that are necessary for a potential circular transition and policy/value chains.	"A circular economy is an economic model that aims to minimise waste and maximise resource efficiency. It promotes strategies such as product redesign, recycling, sharing platforms, and industrial collaboration. Benefits include reduced resource depletion, lower emissions, and increased job opportunities. Challenges remain in policy, infrastructure, and consumer behaviour."

4 FINDINGS

In both SQs, the participants were encouraged to describe their knowledge related to CE to gain insight into participants' expertise in the subject before and after the intervention. In addition to the qualitative questions, both SQs asked participants to quantitatively rate their motivation to work with circularity as well as their confidence in being able to apply CE principles in their own practice on a scale from 1 to 5 (1=lowest, 5=highest). In the second SQ, participants were asked to also rate the close-ended question: *Does the workshop (or journal) help to create a circular mindset for future work in*

makerspaces/creative contexts.' For the analysis, answers to close-ended questions were considered *high* rated when they received either '4' or '5', medium rated for '3', and low rated when they received '1' and '2' responses.

4.1 Knowledge increase

A) Workshop: Comparing the answers to the SQs prior to and after attending the workshop indicated a positive shift in knowledge gained by the participants:

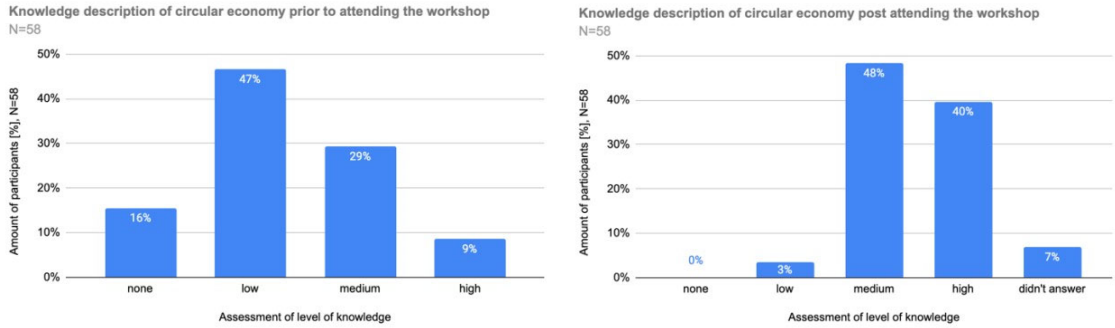

Figure 3. Assessment of CE knowledge prior and post intervention A

B) Self-guided journal: Comparing the answers to the SQs prior to and after completing the self-guided journal also showed a shift in knowledge gained by the participants based on their answers:

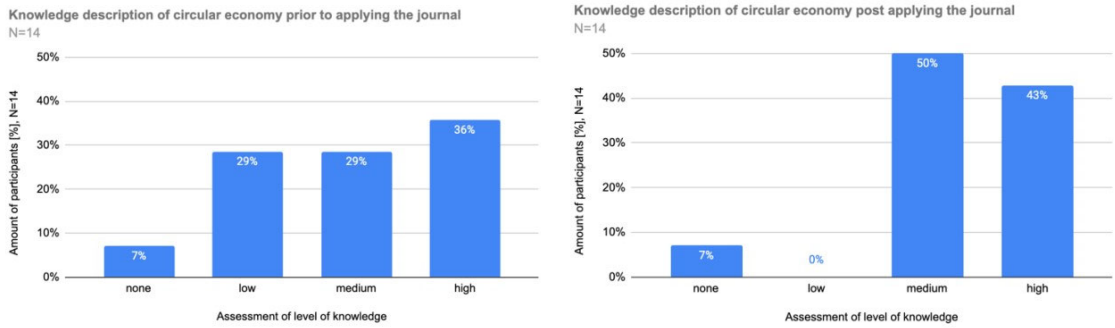

Figure 4. Assessment of CE knowledge prior and post intervention B

A Fisher's exact test was carried out for both intervention A and B to investigate whether statistical evidence could be found between the categorial variables. For intervention A, the workshop, the differences were significant (p-value <0.0001), yet for intervention B, the self-guided journal, no significance was detected (p-value 0.535). Therefore, the workshop performed as intended, but no evidence that the journal performed as well as the workshop could be found based on the self-assessed knowledge increases among participants.

4.2 Change in level of motivation and confidence

Participants were asked to self-asses their levels of motivation and confidence for applying CE principles before and after participating in either the workshop or the self-guided journal. Questions included: *"How motivated are you to work with circular economy in your project?"* and: *"How confident are you that you can apply circular economy principles to your project?"*. Paired t-tests were performed on the two factors to determine if the self-assessed results were significant. The statistical analysis revealed no significant difference between the two concepts for increasing the levels of motivation. However, participants in the workshop reported significantly higher levels of confidence for applying CE principles in their projects (p-value of 0.0046).

5 DISCUSSIONS

Access to design-driven tools that provide an overview of CE strategies can support makers in developing circular mindsets. This study compared two different intervention methods for distributing a framework representing 18 circular strategies in a Fab Lab context. The two intervention formats

included a facilitated workshop and a personal design journal, aiming to educate makers as reflective practitioners. Both interventions were offered in physical and virtual format, and the completion rates were lower for online participants in both interventions.

Knowledge increases were detected in both interventions, suggesting that a self-guided journal could be as effective as a facilitated workshop. The workshop format did however increase self-assessed knowledge among participants and positively influenced makers' level of confidence for applying circular strategies in their own contexts after they completed the workshop.

These findings are promising since both interventions support the creation of a circular mindset among makers. Facilitating a workshop requires preparation and a skilled facilitator, whereas a self-guided journal, once created, can be more easily distributed, to many participants. As such, the journal then remains independent from facilitation resources but might require more time from the makers who are filling out the journal. Future work needs to focus on improving the journal format so that it matches or betters the workshop in increasing self-assessed knowledge and confidence levels of participants.

6 LIMITATIONS

The study is limited by the small number of participants who completed both survey questionnaires, the unequal sample sizes, and different age ranges in the two groups.

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