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A tool for collaborative circular proposition design

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ABSTRACT

Circular oriented innovation aims to address sustainability problems such as resource scarcity, pollution and climate change by (re)designing industrial products, processes, business models, and value network configurations. Although the literature identifies collaboration as crucial for circular oriented innovation—due to the complexity, risk and uncertainties involved—few tools have been developed to support it. To address this gap, we develop and test a tool that helps companies ideate to identify partners and value within circular oriented innovation. The tool integrates decision-making principles from the entrepreneurship theory of effectuation within a design thinking approach to stimulate collaborative ideation of circular propositions. We demonstrate and test the tool through six workshops, and collect data via observations, field-notes, assessment forms and user discussions. Our results show that: 1) users are receptive to visualisation and effectuation-based questions to collaboratively ideate circular propositions; 2) expert facilitation helps to maintain a circularity focus to avoid 'business-as-usual' ideas; and 3) differences in the maturity and scope of projects may influence the usefulness of the tool. We contribute to theory by demonstrating the integration of effectuation, design thinking, and lean experimentation approaches into a tool to advance circular oriented innovation. We contribute to practice with the tool itself that supports early and quick ideation to identify partners and perceived value. This supports companies to collaborate and advance the design of circular propositions that bring circular business model ideas closer to implementation.

1. Introduction

Circular oriented innovation (COI) is a problem-centric and action-oriented iterative process. Its aim is creating business opportunities held within the transition toward a circular economy (CE) to address sustainability challenges, such as resource scarcity, pollution, and climate change (Bocken et al., 2018; Ghisellini et al., 2016). COI explores the (re)design of industrial products, processes, business models, and value networks (Blomsma et al., 2019b; Geissdoerfer et al., 2017), by narrowing (using less), slowing (using products longer), and closing resource loops (using materials again) (Bocken et al., 2016; Lüdeke-freund et al., 2018). Such cycling of products, components, and materials maintain their integrity across multiple life-cycles till end-of-life recovery to maximise value capture and reduce environmental impacts (Den Hollander, 2018; Lüdeke-freund et al., 2018). COI relies on recovery strategies such as reuse, reparability, refurbishment, remanufacturing, and recycling (Lüdeke-freund et al., 2018). These competencies go beyond traditional relationships to connect upstream and downstream actors (Urbinati et al., 2017). Complementary innovations and business models are needed for recovery strategies to function across multiple life-cycles and at scale (Bocken et al., 2019; Boons and Bocken, 2018). Such CE strategies have generated excitement, but need to be operationalised through validation to implement and realise proposed sustainability benefits (Blomsma and Brennan, 2017).

COI is nascent, however, research into how to operationalise it is growing. Researchers are integrating theory into tools, methods, and concrete practices within iterative innovation processes to support COI. COI needs collaboration to implement recovery strategies, and assess whether a circular proposition (the combination of circular product, business model and value network arrangements) can

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function at scale and achieve intended sustainability goals (Blomsma et al., 2019a; Zucchella and Previtali, 2018). However, implementing such circular propositions in practice is very challenging due to the complexity, risks and uncertainties that come with collaboration (Baldassarre et al., 2020; Tukker, 2015). This results in a design-implementation gap that requires support mechanisms, such as tools (Baldassarre et al., 2020; Geissdoerfer et al., 2018). Systematic reviews on sustainability and COI tools highlight that for them to be well-designed they should be specific to the intended purpose and require empirical evaluation (Bocken et al., 2019a,b; Pieroni et al., 2019). Although tools have been developed, few focus on collaboration. Specifically, none have been found that support companies to overcome difficulties occurring at the early stages of ideation to collaboratively identify partners and perceived values that are required to progress COI.

This study represents a first exploration into this gap. The goal is to develop a tool that helps companies ideate to identify partners and integrate perceived values into circular proposition design. In such uncertain conditions, an effectual attitude is recommended (Chesbrough, 2010, p. 362), since it is a more iterative and emergent approach as opposed to a more structured linear innovation funnel or stage-gate approach (Keskin et al., 2020; Sarasvathy, 2009; York et al., 2016). Moreover, an effectual process focuses on available means and collaborative learning cycles over extensive analysis before innovating. Using design science research (Hevner, 2007; Romme and Reymen, 2018), we develop a tool that integrates effectual decision-making logic within a design thinking approach to explore whether it can support COI. We, therefore, ask: *How can a tool* support *companies to identify partners and ideate collaborative value for circular proposition design?*

To answer this question, first, the emergence of collaborative circular propositions and the development of tools and their approaches, are reviewed. Second, the design science research approach is explained and the tool development process and the structure of the demonstration workshops are provided. Third, data from the demonstration and evaluation of the tool are analysed and the improved tool is presented. The discussion, limitations, future research directions, and conclusions follow.

2. Literature background

Section 2.1 briefly reviews the emergence of collaborative circular proposition design. Then, section 2.2 investigates contributions from tool review papers that explore related sustainability research that is connected to the development of COI. Section 2.3 presents key elements from the literature for collaborative ideation tool and process development. Lastly, section 2.4 presents the research gap and identifies the objectives to be brought into our tool development process.

2.1. Emergence of collaborative circular proposition design

COI builds on sustainable oriented innovation concepts by integrating CE principles and recovery strategies (Brown et al., 2019). Central to both is the development of a core sustainable purpose (why one innovates). Adams et al. (2016) and Ceschin et al. (2016) show how sustainable oriented innovation has evolved through product level eco-design approaches towards product-service systems (integrating business models and supply chains) towards an increasing focus on the exploration of socio-technical system changes (proposed by ideas such as CE) to increase sustainable impacts. Seuring (2013) states this needs to move beyond a sense of trade-offs between stakeholders to satisfy multiple and conflicting objectives to explore win/win and synergistic opportunities. Stubbs and Cocklin (2008) state this requires integrating and connecting a view on how business models create value beyond the focal company for stakeholders such as customers, society, and the environment. Additionally, within COI processes this requires companies to also go further upstream and downstream within existing or create new supply networks (Ünal et al., 2019; Urbinati et al., 2017) to explore and create complementary innovation activities (Takey and Carvalho, 2016); so value flows (Webster, 2015).

Understanding value and how it is created and flows is central to the business model concept, which aims to describe how business is done by characterising a company's value proposition, creation, capture, and delivery activities (Richardson, 2008). Here, Bocken et al. (2013) and Short et al. (2013) explore how combining a sustainable purpose with concepts of value missed, destroyed, wasted, and uncaptured (the latter expanded by Yang et al. (2017)) for stakeholders can identify opportunities to innovate business models to increase sustainable impacts. When integrating stakeholders into innovation activities Tyl et al. (2015) put forward three ways of ideating upon stakeholders; firstly their identification, secondly analysis of their values, and thirdly designing potential stakeholder interactions. Such processes aim to identify the interdependent activities and components that can stimulate ideas for what could be changed, in collaboration with stakeholders, to increase the efficiency of value flows and innovate solutions (Zott and Amit, 2010). Moreover, understanding how to increase and share value capture across stakeholders can aid new collaborative value propositions that incentivise COI (Kraaijenhagen et al., 2016; Rohrbeck et al., 2013). Within COI, understanding collaborative value potential is crucial when developing a circular proposition. Since the focus is on how to coordinate and combine circular strategies across multiple life-cycles. Each stage needs to have value capture opportunities available to incentivise partner activities; such as initially recovering products to refurbish for reuse or as a last resort recovering the material value. These activities require resources (energy, logistics, labour etc). So the actor who performs the activity also needs to capture value directly or indirectly. Yet, this needs to be considered within the initial ideation and design phase.

2.2. Tool reviews from eco-design, supply chain, product service systems, and business model innovation to understand circular oriented innovation tools

An early review into sustainability tools by Baumann et al. (2002) highlights that the conceptual stage is the most influential to change a product's environmental performance and needs to include a systemic focus on the business strategy and the full product life-cycle. Yet, they state tools were lacking and those that existed tended to be difficult to use. This difficulty of use is later corroborated by Rossi et al. (2016), although they find that the use of tools are still the primary means that companies engage with sustainability and eco-design concepts. Their review shows tools include life-cycle assessment, diagrams, checklists or guidelines that present intelligent questions to designers to anticipate and solve problems within the early phases of a product development process. Further, they suggest to use them effectively requires collaboration amongst people with different skills sets and taking an increased focus upon the supply chain. Alves and Nunes (2013), find similar tools within service design and also identify a gap upon integrating the supply chain focus. Yet, Taticchi et al. (2015), who review supply chain decision-making tools find few adequately support connections between supply chain decisions and product design, performance or business strategy across stakeholders. They state decision-makers need tools that aid a holistic approach towards overcoming disadvantages of traditional trade-off

approaches, whilst bringing a focus on stakeholders, understanding relationships, and crucially value flows and customer needs. Vezzoli et al. (2015) investigate the development of sustainable product service systems (PSS). They find a key challenge is the design of novel stakeholder interactions and creating cyclical testing using tools to co-create value. Fernandes et al. (2020) review CE oriented PSS, they advance this increased importance on integrating different stakeholders viewpoints (commonly through visualisation tools) to overcome increased complexity and uncertainty held within a circular approach to aid decision-making. Further, they highlight that tools intent on the development of collaborative systems of stakeholders need to design shared value systems that go beyond customer value. They, however, indicate such a collaborative approach within tools are limited and in their infancy.

Systematic reviews by Pieroni et al. (2019) and Bocken et al. (2019a,b) that investigate sustainable and circular business model innovation tools show many explore value using the 'building blocks' proposed within Osterwalder's (2010) business model canvas. Pieroni et al. (2019), notes that tools designed for sustainable and circular business model (re)design are also increasingly built using the activity systems perspective proposed by Zott and Amit (2010). Focus is drawn to what interdependent activities and capabilities, across company boundaries, should be performed, how they are linked, who performs them, and how they can be (re) configured to create new value (Zott and Amit, 2010). This promotes a collaborative view needed for sustainability by considering multiple stakeholders throughout the innovation process. Yet, Tyl et al. (2015) highlight within their review that the process to identify stakeholders is not always explicit and commonly lacks guidance on how to integrate stakeholder value into the early ideation and design stages. They state few tools assess stakeholder value, other than the value mapping tool (Bocken et al., 2013) and social stakeholder business canvas within the triple layered business model canvas developed by Joyce et al. (2016).

To manage the complexity and uncertainty within COI processes many researchers have proposed specific frameworks, tools, or methods. These include aspects on rethinking complexity in CE (Velte et al., 2016), circular design competencies (Moreno, De los Rios, Rowe and Charnley, 2016; Sumter et al., 2020), behaviour change (Wastling et al., 2018) or consumer engagement (Sinclair et al., 2018). Other researchers explore the combination of design and business model strategies (Bocken et al., 2016) and the development of circular PSS (Blomsma et al., 2019; Pigosso and Mcaloone, 2016). Similarly, researchers have deep-dived into circular business model innovation and experimentation processes (e.g. Guldmann et al., 2019; Nußholz, 2018). The need for increased collaboration is clearly identified. Collaboration is focused on by Witjes and Lozano (2016) who explore collaboration within procurement and Leising et al. (2018) who investigate collaborative supply chains. Yet, their approaches do not provide practical guidance on how to identify partners or integrate their different perceived values to model collaborative value in early COI. Work on collaborative circular business models by Kraaijenhagen et al. (2016) state the need to identify partners and offers a range of questions and proposes plotting answers in a matrix (p.70–71) to start thinking about potential interests before engaging them. Yet, this approach does not explore the benefits of collaborative ideation. Further, Bocken et al. (2019a,b), argue still many specific circular tools are not used, due to increased complexity, required resources, knowledge, expertise, or are too context-specific.

2.3. Collaborative ideation tools, methods and process development

Tools designed to support sustainable or circular innovation processes can incorporate knowledge from more generic tools, innovation approaches, and different disciplines. Notably, researchers have started to draw together Design Thinking, Lean Experimentation, and Effectuation to offer support to collaborative ideation within highly uncertain innovation processes, such as COI (e.g. Baldassarre et al., 2017; Bocken and Antikainen, 2018; Geissdoerfer et al., 2016). These different approaches are presented below.

Design thinking is seen as a way to ideate (the process of forming new abstract or concrete ideas and concepts) within contexts of high uncertainty or even wicked problems (Micheli et al., 2019; Von Thienen, Meinel and Nicolai, 2014). It integrates different perspectives and matches users' needs to what is feasible and viable by combining analytical and intuitive thinking to generate novel ideas that create market opportunities (Brown, 2008). This is done through creatively reframing the challenge and empathic thinking. The aim is to overcome existing practices, challenge assumptions and explore uncertainty through co-creating prototypes and experiments (Elsbach and Stigliani, 2018; Tschimmel, 2012). Collaboration with stakeholders is central to gaining wider perspectives on a problem or assessing potential needs (Elsbach and Stigliani, 2018; Micheli et al., 2019). Needs can be brought into the thinking process either directly by engaging stakeholders or indirectly by empathetic sensemaking activities (Beverland et al., 2016). Chasanidou et al. (2015) indicate it is the identification and mapping of key stakeholders, their relationships, and needs that are essential to identify new insights or future actions. Design thinking tools and methods such as brainstorming, mind-mapping and visualisation create 'conversations' and support synthesis of insights by mapping a situation, problems or ideas to then explore new combinations (Micheli et al., 2019; Tschimmel 2012). Elsbach and Stigliani (2018) find the hands-on creation of physical artefacts (filling in of a canvas, drawings, sketches, concept prototypes) and the emotional experience (surprise, delight, increased empathy) of conducting design thinking processes reveals to those who use the tools specific values, norms, and assumptions that support creativity. In-turn this can aid organisational change that increases the value of experimentation and active learning.

Experimentation is a trial and error problem solving process that generates insights when information is non-existent or unavailable (Thomke et al., 1998). Experimentation uses approaches such as 'probe and learn' (Lynn et al., 1996) and more recently Lean Start-up's 'build, test, measure, learn' processes are used to quickly test new ideas within practice (Ries, 2011, 2017). A lean experimentation approach has been popularised and increasingly used within a business context (Bocken and Snihur, 2020; Felin et al., 2019). The logic is to ideate, test variations, validate learning through experimentation and pivot if needed. These approaches have been integrated within design thinking through participatory workshops (Geissdoerfer et al., 2016), and iterative user-testing (Baldassarre et al., 2017). The aim is to assess the desirability of value propositions (for different stakeholders), the viability and feasibility (Brown, 2008; Calabretta et al., 2016). Such an iterative process can refine abstract sustainability ambitions, ideas, values, and visions into concrete actions and can be used to model potential collaborative value. This is important to understand whether the idea is scalable and would still meet the intended sustainability challenge (Brown et al., 2019; Manninen et al., 2018). Each step in such a process can and should be supported by specific practices with stakeholders to develop concrete actions that advance ideas and learning (Bocken et al., 2019a,b; Geissdoerfer et al., 2016). Tools and methods from lean experimentation can be the use of experiment cards, A/B testing or simple website mock-ups. Combined within a design thinking process and categorised as tools that

support; 1) need-finding, 2) idea generation and 3) idea testing (Bland and Osterwalder, 2019; Elsbach and Stigliani, 2018). A review of collaborative ideation tools by Peters et al. (2020) identifies that analogue (non-digital) tools dominate the early idea generation stages, due to their ability to support quick, flexible, and low-cost ideation to understand and align on a context or future scenario. They show that card-decks and toolkits that incorporate prompts (e.g. trigger questions) or concepts (e.g. short descriptions of theory) are the most common collaborative ideation tools. These act as physical artefacts, combining visualisation and mapping within a design thinking process to develop lean experiments. Intensive use of post-its supports emergent idea generation by allowing participants to think more broadly and radically (ideas can be added and combined quickly); but the workshop design should include periods of self and group reflection to allow participants space to diverge and converge (Micheli et al., 2019; Tschimmel 2012).

Effectuation proposes a 'resource-based' view that assesses what is available to create collaborative action (Sarasvathy, 2001). Effectual logic is counter to traditional innovation pursuits that extensively evaluates opportunities before actions to innovate products or services (Fisher, 2012; Sarasvathy, 2009). The focus is upon a decision-making logic towards assumption testing via experimentation using available means and immediate actions, so if ventures fail they do so early and at a lower cost (Fisher, 2012; Sarasvathy, 2009). Chesbrough (2010) advises using an effectual approach to conduct business experimentation in high uncertainty, due to the emphasis on action over analysis. Effectual logic starting from available means is led by affordable loss principles instead of expected returns; it leverages relationships over competition and intends to uncover possible opportunities held within uncertainty, whereby goals are emergent and shaped over-time through interaction (Sarasvathy, 2009). Effectuation promotes five core principles (Sarasvathy, 2009) these are: 1) the bird-in-the-hand (use available means) focusing action on what can I do with what I have, 2) affordable loss (what can I accept to lose), 3) crazy-quilt (stakeholder commitments expand means and shape the enterprise), 4) Lemonade (leverage uncertainty and exploit unexpected opportunities), and 5) the pilot-in-the-plane (actor agency shapes the future). Sarasvathy et al. (2014) indicate that an effectual process is a dynamic double-loop process. This effectual process is represented in Fig. 1.

York et al. (2016) explore the use of the effectual process and logic by sustainable entrepreneurs. They find an entrepreneur's identity and focus upon commercial and sustainability logics can result in differing priorities that affect how they approach stakeholders. Keskin et al. (2020) investigate how sustainable entrepreneurs use different logics to advance different tasks within sustainable ventures. They found that for a long-term and predefined value proposition (e.g. to sustainably adapt a specific market or customer experience) it is common to use an 'adaptive' approach (more linked to causation) using high-fidelity experiments (e.g. working prototypes) to test the technical performance, feasibility, and viability; but rarely explore changing the proposition. Whereas, if searching for different value propositions entrepreneurs use short-term low-fidelity design experiments (paper prototypes or models) to explore different product concepts, customer segments, and stakeholder engagement. Promotion of stakeholder self-selection processes co-develop the value proposition using an 'expative' approach (more linked to effectuation). Silva et al. (2019) and Mansoori and Lackeus (2020), through their reviews into innovation and entrepreneurial approaches, build on this idea of combining or varying approaches. Both argue practice-based approaches (such as designing thinking and lean experimentation) are more widely used since they provide practical tactics and guidance to advance and the different approaches could be complementary over-time as the level of investment increases an idea or start-up progresses. Such an integrated approach has been explored by Bocken et al. (2017), but not within the development of a specific tool. Souza et al. (2019) and Mansoori and Lackeus (2020) also identify that while stakeholder interactions are crucial to effectuation, design thinking and lean, especially in the early stages to identify real problems, needs and potential solutions; yet, how to identify, integrate, and initiate stakeholders engagement within such a process are under-researched.

2.4. Research gap

Conducting COI means to integrate collaborative processes and value flows to ideate and design a circular proposition. Our review of sustainable and circular tool development literature indicates that COI is difficult because it is uncertain and complex, requiring collaborations to overcome this. Yet, there is a knowledge gap on how such collaborations can be supported. Specific gaps relate to

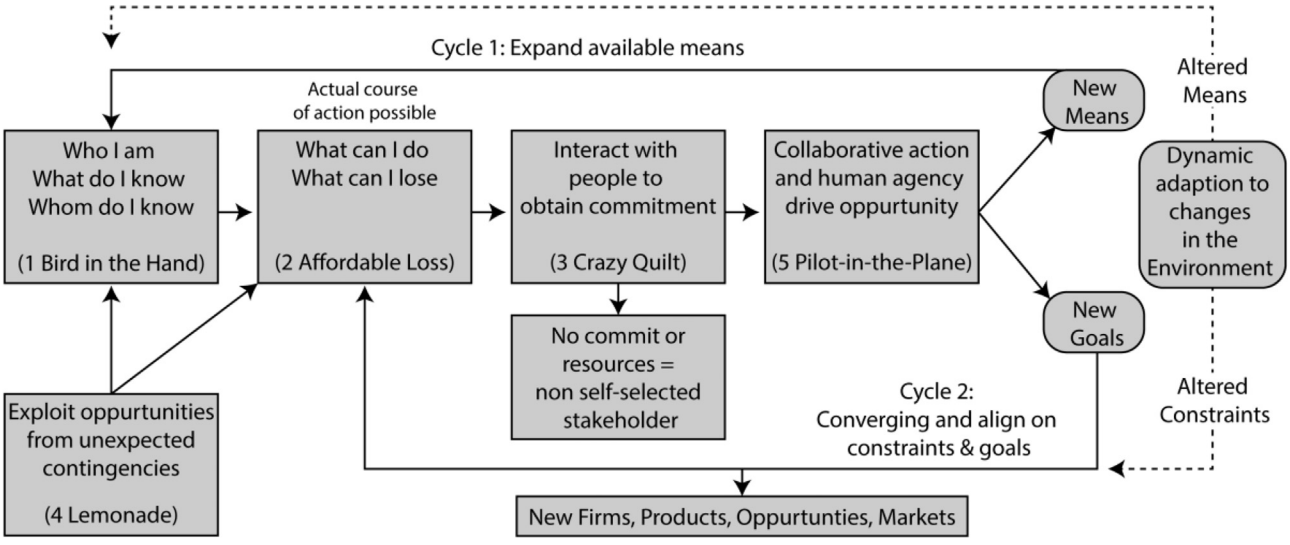

Fig. 1. *Effectual Process. Authors visual based on Sarasvathy* (2009; 2014).

the lack of relevant tools to support it and to integrate concepts like effectuation, design thinking and experimentation.

Firstly, Pieroni et al. (2019) state within tool development there is a lack of focus upon collaborative ideation to model and co-create value beyond customers to incorporate upstream, downstream and wider stakeholders such as the environment or society. Sustainable tool design principles and process-related criteria presented by Breuer et al. (2018) highlight this should be a minimum requirement; to include context-sensitive externalities (traditionally outside the business model) and case-specific stakeholders. They argue this is essential to conduct collaborative modelling of value. Fernandes et al. (2020) advance this gap stating circular tools need to identify, integrate, and prioritise the needs, problems and perceived value for stakeholders; and to identify ways to collaborate to co-experiment with different value configurations. They argue the design of the circular proposition and the system design (developed through collaboration) are still largely being considered independently. They propose to integrate these through combining process models and visualisation approaches to aid the modelling of perceived value within a system. Yet, in COI due to the complexity of complementary connections within a circular proposition (the product design, business models, and value networks arrangements to facilitate recovery) this increases uncertainty, and therefore the need for tools to support practitioners.

Secondly, this increased uncertainty lends itself to combining effectual, design thinking and lean experimentation concepts into the development of an analogue tool for collaborative ideation to integrate and maximise their advantages. Developing such a collaborative ideation tool could decrease the uncertainty, orientate and inspire, but also resolve conflicts, align interests and produce tangible action planning and experimentation. Aligning interests is an act of finding balance, hence ideas need to be crafted to find or enhance synergies or overlaps between stakeholders (Keskin et al., 2020; York et al., 2016). This may require reframing or shifting sustainability goals or engaging different partners to improve market and/or sustainability performance (York et al., 2016). Thus a tool should be flexible and adaptable to support entrepreneurs (Breuer et al., 2018; Keskin, 2015). Moreover, to overcome the theory-practice gap for tool use Breuer et al. (2018), Pieroni et al. (2019), Bocken et al. (2019a,b) and Mansoori and Lackéus (2020) propose the integration of approaches to advance systemic thinking, the ability to ideate and craft collaborative value and align the stage of the ideation to the approach used. Lastly, our review into tools shows none are specifically designed and tested to support ideation to identify partners and integrate perceived values into the early crafting processes for circular proposition design.

3. Research design

This section briefly introduces design science research, the workshop format, demonstration contexts, and the data collection and analysis.

3.1. Design science research

Design science research (DSR) bridges theory and practice by designing and validating artefacts (that can include conceptual frameworks, models, and tools) using a pragmatic problem-solving and iterative approach to explore solutions to unsolved business problems (Hevner, 2007; Romme and Reymen, 2018). DSR has been applied to entrepreneurship challenges engaging innovation phenomena and has proven valuable to structure scientific research, codify practice knowledge, and integrate theory into useable artefacts (Romme and Reymen, 2018; Van Aken and Romme, 2009); notably within Osterwalder's (2004) academic research, which led to the business model canvas (Osterwalder and Pigneur, 2010).

We chose DSR methodology, due to its structured and rigorous approach towards tool development. The use of DSR to develop our tool is visualised in Fig. 2. The DSR design and validation process incorporates iterative evaluation and redesign of an artefact to

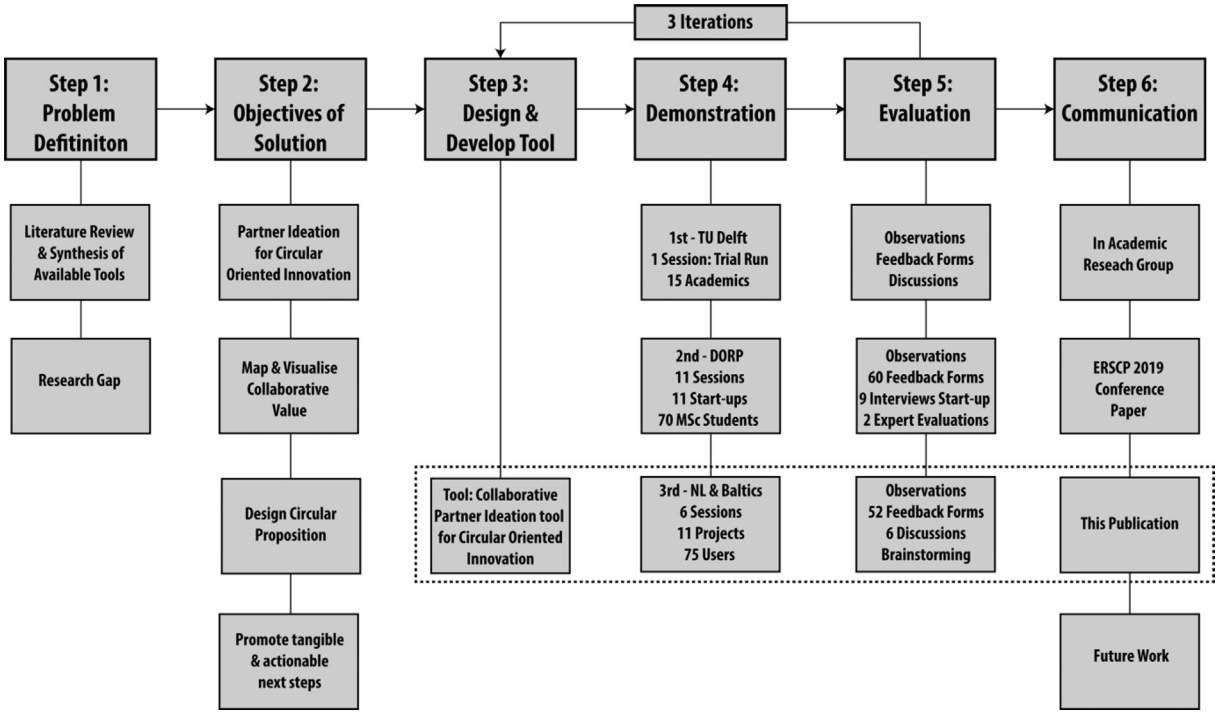

Fig. 2. Tool Development Process undertaken based on Design Science Research iterative design approach (Hevner, 2007; Peffers et al., 2007; Van Aken and Romme, 2009). Steps 1 & 2 are reported above in section 2. For steps 3 to 6 this publication communicates the 3rd cycle of design, demonstration and evaluation only (represented by the dotted line within figure) – See Supplementary Information for an overview of research cycles, previous tool design iterations and workshop templates & forms.

increase usability, quality, and efficacy (Hevner, 2007; Romme and Reymen, 2018). Peffers et al. (2007) promote an iterative process (incorporating six steps see Fig. 2) with the need to demonstrate the artefact within a suitable context (with users) to evaluate how the artefact is used and whether it is successful. In the first step Van Aken and Romme (2009) add a literature review and synthesis of available artefacts to identify gaps, aid ideas, and highlight possible solutions to be integrated into the new artefact. To support evaluation (step 5), Peffers et al. (2012) identify a range of suitable quantitative and qualitative evaluation methods. We use ethnographic observations of use, feedback forms and discussions at the end of the workshop with users to evaluate the perceived usefulness and ease-of-use of the tool (Davis, 1989; Venkatesh et al., 2003). Additionally, the researchers who facilitated the workshop also reflect and brainstorm upon design and facilitation improvements between each session; based on their observations, experiences, and field-notes. Each design-demonstration-evaluation cycle aims to improve the tool's design or facilitation. This approach is consistent with the circular business model innovation tool development checklist proposed by Bocken et al. (2019a,b), whereby tools should be purposively and rigorously developed (integrating literature, practices, and knowledge from different disciplines) and evaluated with users.

The literature review and tool synthesis identifies an unsolved problem: COI tools do not explicitly focus upon partner identification or collaborative value when designing a circular proposition, although this is crucial. Our objective is to develop a tool that supports COI partner identification and to ideate, map and visualise collaborative value to aid the design of circular propositions and promote tangible and actionable next steps. This study communicates data collection from the 3rd design iteration of the tool, which is demonstrated through six workshop sessions with practitioners and CE researchers (see dotted line in Fig. 1).

3.2. Workshop structure & demonstration contexts

The demonstration workshops follow the same overall structure to create consistency within data collection. Before the workshop begins, participants have filled in an in-take form to understand specific user challenges or CE ideas. Team form and then work on a live project brought forth by challenge owners who are active participants within the workshop. Challenges were identified from the in-take form. Participants self-selected into groups based on their own interest or desires to work on the project. The locations, participants, and project focus are displayed in Table 1. The identified CE challenge is used in teams of 5–7 participants within a 2-h workshop (before using the collaboration tool) that uses a card-deck to educate and help understand circular innovation strategy combinations (Konietzko, Bocken and Hultink, 2020a). The output from the card-deck are initial ideas for circular propositions, presented within 'Circular Pitch' templates.

The proposed structure and timeline is presented in Fig. 3 (see Fig. 4 collaboration canvas in section 4.1 to understand sections of the tool). Each team selects an idea to advance using the canvas. How to use the canvas is explained and then teams use it, while being facilitated. Once the sections have been completed the researchers, who are facilitating, re-issue the 'Circular Pitch' and provide the 'Action Template'. These are to aid users to distil insights from the canvas, craft their circular proposition, and plan actions. At the end of the workshop feedback forms are issued and subsequently a discussion is conducted on the experience of using the tool. We were not able to collect all feedback forms from all participants, since some users needed to leave the workshop demonstration early. Please see supplementary information for all forms and workshop protocols.

3.3. Data collection

Data is collected during the workshop by researchers making field-notes and observations on the use of the tool and required facilitation. The researchers also collected insights from the filled-out tools, the circular pitch and action templates. Tool assessment forms are filled in. Forms included a Likert score of 1 (do not agree at all) to 7 (fully agree) assessing perceived usefulness and ease-of-use (Davis, 1989; Venkatesh et al., 2003). Space was provided to discuss the users design recommendations, learning and insights,

Table 1
Overview of demonstration workshops, participants and project focus.

Workshop	Location	Participants Background	Number of Participants & Groups	Teams Focus in Workshop Demonstration
1	Netherlands: Amsterdam company location	Mixed professionals (design, procurement, and business strategy) from large Dutch Multi-national	10 & 2	Both groups explored new circular business models for high-end consumer beauty products
2	Germany: Hamburg Impact Hub	Start-ups, Entrepreneurs and PhD researchers	15 & 3	Built Environment - Modular partition wall system Zero waste biological plastic packaging Circular Textiles and Fashion
3	Latvia: Riga Conference	Start-ups, Entrepreneurs and Innovation Managers	14 & 3	Toxic materials in sealant for insulation windows Reuse of materials from built environment Creating modular and repairable multi-season clothing
4	Finland: Aalto University	Professors, PhD and MSc researchers working on a Large Finnish CE Textile Project	12 & 3	All Groups explored challenges linked to the Finnish textile project, but separated to explore different aspects
5	Finland: Aalto University	Innovation Managers, Sustainable and CE Consultants, PhD and MSc researchers	12 & 2	Built Environment focus upon a circular building Explored Finnish textile project
6	Finland: Lappeenranta University of Technology (LUT)	Lappeenranta Regional Innovation Director, Directors of International Welding Company and Professors, Post-Doc and PhD researchers focusing on circular economy	12 & 2	Focused on the region of Lappeenranta built environment challenge to maximise use of existing building stock New product and service models for the welding company

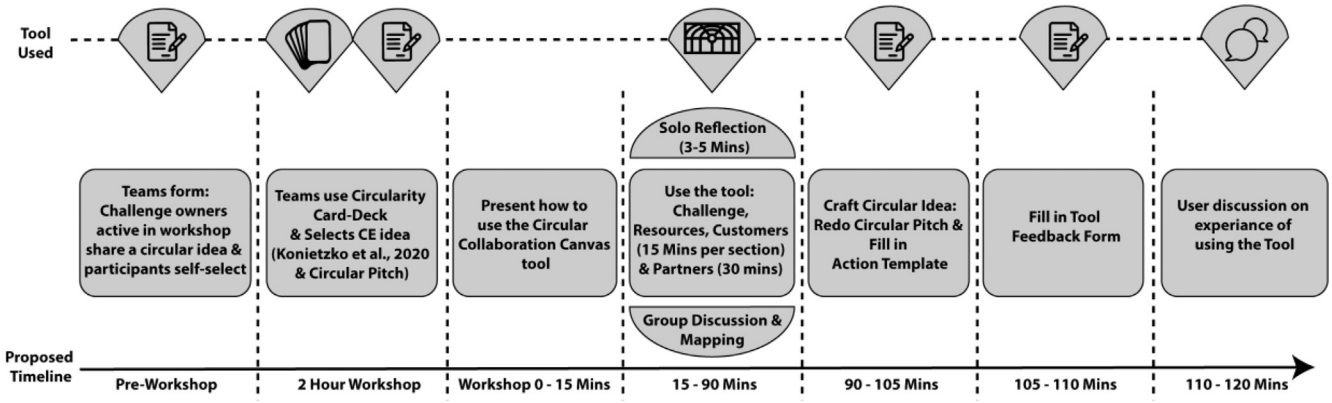

Fig. 3. Proposed timeline for workshop demonstration.

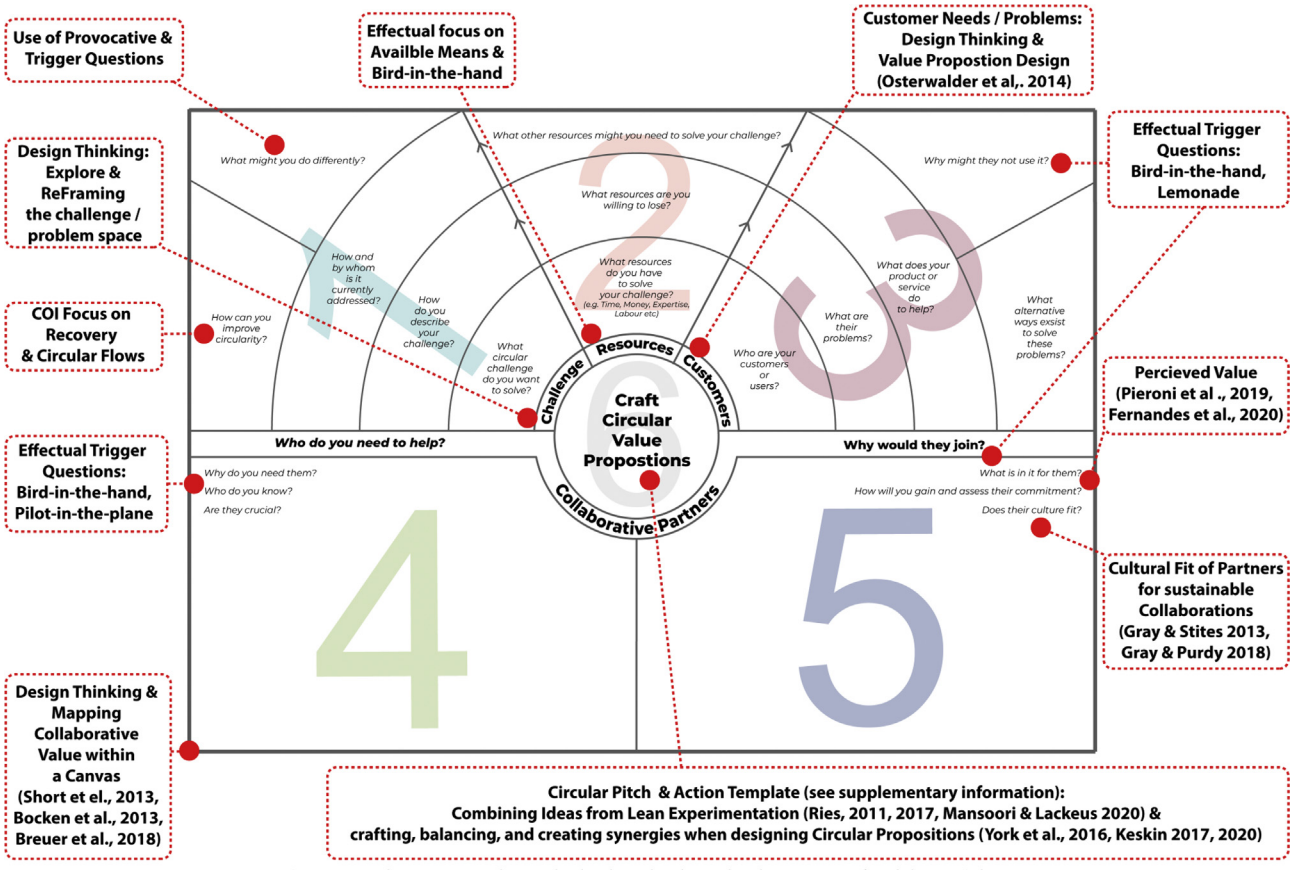

Fig. 4. Tool Demonstrated in Netherlands and Baltic: Plus descriptions of tool design & logic.

and explain whether their idea had changed through using the tool. At the end of the workshop session the researchers ran a group discussion to gain further insights into the use of the tool.

After the workshop the primary researcher reviewed the feedback forms. Then the two researchers (Author 1 & 3), who facilitated workshops consolidated their observations, field-notes, and insights to brainstorm potential design or facilitation improvements. Focus was drawn to: 1) the order and actions users undertook, 2) discussion points raised around perceived usefulness or ease-of-use, and 3) direct questions, comments, or reflections from participants that raised challenges or improvements. These notes formed key insights into the perceived usability and ease-of-use that prompted recommendations (section 4.4) and iterations between workshop sessions to improve the tool. Please see supplementary information for all forms and workshop protocols.

4. Tool development process

Tool development is an iterative process, which in this study represents six design-demonstration-evaluation sessions, previously shown in Fig. 2.

4.1. Initial tool tested

The purpose of the tool is to identify partners and ideate upon value for stakeholders. The tool incorporates an underlying logic of visualisation and integration of stakeholder perspectives beyond

the company within ideation (Bocken et al., 2013; Short et al., 2013). The tool presents a canvas that uses trigger questions across key topics; Challenge, Resources, Customers, and Collaborative Partners. The logic and trigger questions are derived from; effectuation (Sarasvathy, 2009), customer pains (Bland and Osterwalder, 2019; Osterwalder et al., 2014), and collaborative partnerships for sustainability (Gray and Purdy, 2018; Gray and Stites, 2013). These are used to generate ideas using design thinking practices (Brown, 2008; Elsbach and Stigliani, 2018; Geissdoerfer et al., 2016) to identify and balance partner synergies (Keskin et al., 2020; York et al., 2016) and explore perceived value (Breuer et al., 2018; Fernandes et al., 2020). Effectual trigger questions can include: 1) personal knowledge (who am I? what do I know?), 2) skills (what can I do?), and 3) social networks (whom do I know?) (Sarasvathy, 2009), these are adapted and integrated into the tool, see Fig. 4 (see supplementary information for previous tool design iterations).

4.2. Results from tool demonstration and evaluation

This section presents the results from the workshops. Fig. 5 shows examples of workshop sessions. Each represents a design-demonstration-evaluation cycle. Firstly, user ratings and insights from the feedback forms are presented. Subsequently, the tool is evaluated based on observations, facilitators field-notes and user discussions. Finally, an example of the use of the tool is provided.

4.2.1. Feedback form results

Feedback form results are presented in Figs. 6 and 7. User scores across the 6 workshop sessions (52 evaluations) indicate that the tool is useful (average score: 6/7; standard deviation: 0.71), but the ease-of-use is rated less highly (average score: 5.6/7; standard deviation: 0.88). User scores show an improvement as the workshop sessions progress. This indicates that the design-demonstration-evaluation cycles and tool edits and facilitation adaptions between the workshop sessions have improved the user experience, usefulness and ease-of-use of the tool. Example comments from feedback forms are provided in supplementary information.

4.2.2. Insights from observations, field-notes and discussions

Observations and user discussions highlighted the perceived value of the tool. A common question across the workshops was whether the users could receive the canvas to use for other projects. One Hamburg user asked *"Can we use it with our partners or are you going to protect it and commercialise it? This is a really good first step*

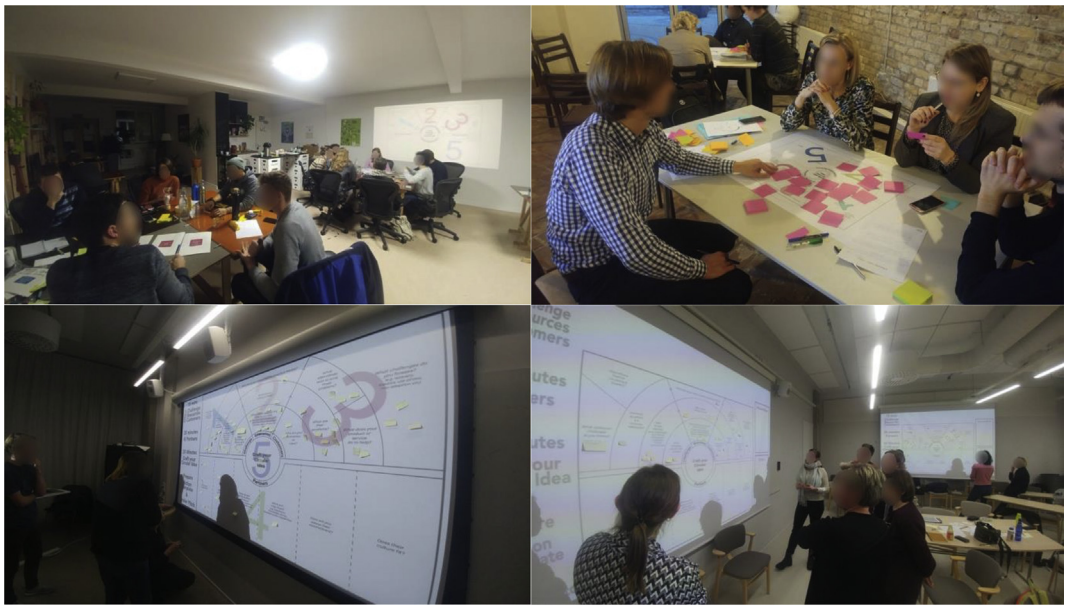

Fig. 5. Examples of the tool being used within demonstration contexts.

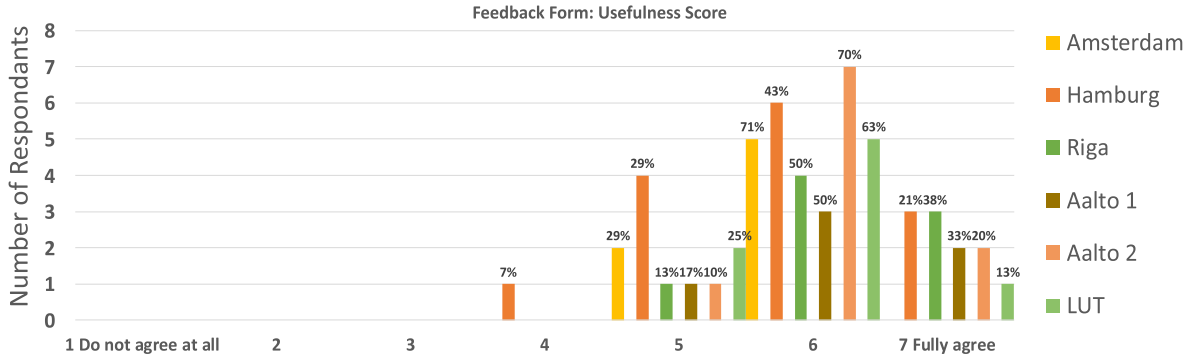

Fig. 6. Usefulness rating for the Tool.

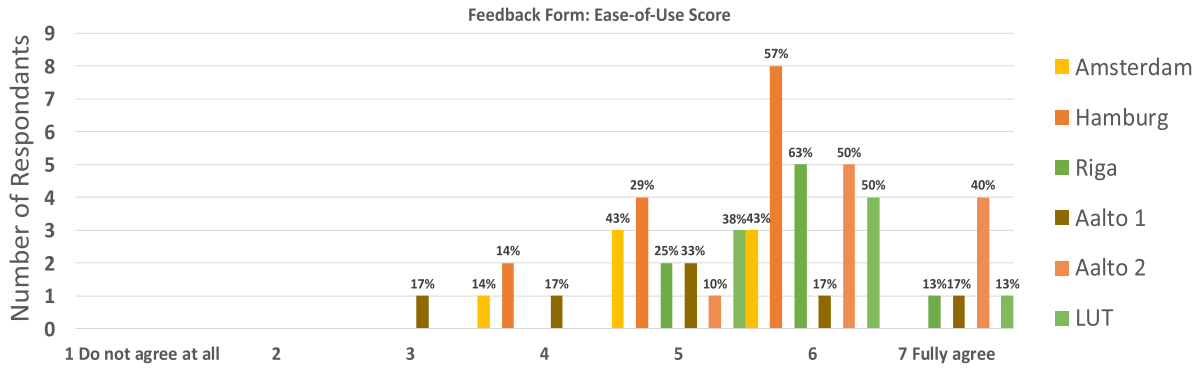

Fig. 7. Ease-of-use rating for the Tool.

to making your idea more relevant and workable". Another user at Aalto stated *"I should really get my colleagues to use this as it is very useful and we need this type of thinking".* This indicates that users already assessed that the tool offers professional level insights. Our further evaluation of the tool highlights four key insights into the use and design of the tool, which are corroborated through observations and user discussions. These relate to: 1) the workflow and topics, 2) Use of trigger questions, 3) Use of mapping and visualisation, and 4) the complexity to craft circular propositions.

1) Workflow of the tool

Groups across the workshop demonstration sessions were observed initially following the proposed workflow of the tool. The customer section required most time and needed investigation before the partner section. Another element presented for how to use the tool was to initially use self-reflection on the questions and then group discussion. Groups however approached this differently. Groups in Amsterdam, Hamburg, Riga and Lappeenranta followed this approach, but commonly assigned one member to read the questions and act as scribes within group discussions. Yet, Aalto 1 and 2 created subgroups to explore different sections separately, then groups would switch sections. Subsequently, they held group discussions to brainstorm content, consolidate inputs and ideate together. In this way, they could build upon each other's input to advance ideas. Finally, in one group in Lappeenranta, with a mix of professors and company representatives, the academics used the order of the questions to engage the company within a more consultancy style approach. This signifies who is present within the group can change group dynamics and the use of the tool. It was noted that the professors challenged the company to keep the focus on the circular recovery elements throughout to support more radical ideas. This was also raised as a common challenge by others when using the tool. These different approaches were shown to work and within group discussions users stated a preference for balancing between the structured and more open approaches towards using the tool.

2) Use of Trigger questions

Observations throughout the workshops highlighted how the trigger questions were received well and generated quick answers and stimulated discussions. These aided rethinking or advancing the idea to become more realistic. Trigger questions were adapted throughout the workshops to improve them (see examples in Table 3). One such recommendation from Hamburg was to change 'what are you willing to lose' to 'what are you willing to invest' to better position and frame it, especially for start-ups who do not normally have a lot of resources. Later workshop observations and discussions highlighted fewer challenges were related the trigger questions. One Amsterdam user stated *"I like the use of the questions, it forces you to make really tangible outputs"* and one Riga user in the discussion stated *"the questions make you think much deeper on your idea, but can also create lots of unknowns or things that are not clearly defined yet, which is good as these are things you need to work on".* Other users agreed and referenced the need to adapt some questions to capture these elements. User discussions within the Hamburg and Aalto workshops advanced this stating the need for new questions to aid thinking about reasons or stakeholders who might oppose the idea and to create questions that engage potential challenges that arise while going through the tool. Users also discussed circular oriented questions were needed throughout to maintain the CE focus.

3) Use of canvas, visualisation, mapping, and design thinking workshop

Observations showed the users found the canvas valuable. They enjoyed the mapping, visualisation and group work approaches, which aided their ability to learn about and from each other. Many users referenced similarities to the business model canvas, but felt this tool provided more detail and forced you to produce more concrete ideas, due to the need to think deeper via trigger questions. Additionally, many groups used the canvas as a pitching tool. Most notably the groups in Amsterdam used the canvas to pitch their ideas to external supervisors directly after the session. Hamburg, Riga, and Aalto workshops all highlighted how the visualisation and design thinking workshop really worked for quickly bringing the group together and exploring the innovation challenges. Additionally, the use of the 'Circular Pitch' and 'Action templates' were discussed as a good way to bring the visualised content and discussions generated into tangible next steps. One user within Hamburg stated *"I want to use more tools like this, it is a great way to create better ideas".* Whereas a Riga user stated the visualisation and mapping was *"good for deepening our understanding and answering in groups helps to gain other types of thinking that help you make the ideas better".* One user in Lappeenranta advanced this by stating how *"the canvas really helps you have a discussion as it acts as a physical object with the trigger questions that start conversations and discussions. This is especially important here in Finland where people are less conversational".* This highlights how such an approach has properties that allow for and can cope with cultural sensitivity. Finally, a common discussion across workshops was the desire to gain further exposure and experience with the use of such tools.

4) Crafting the circular proposition

A common theme from observations and group discussions was the increased complexity experienced when crafting the circular proposition. Observations and discussions highlighted two main outcomes from the use of the tool for ideation.

One was to deepen their idea and the reality for how to build it. Within the Riga discussion a user stated *"things were much more positive when using the cards [previous workshop], you can just put forward ideas. Now we have to make the idea more realistic. This is much harder and challenging, but good as it creates a reality check for your idea"*. Here, an Aalto workshop user stated *"it feels like a puzzle that you have to try find all the pieces through using the tool to test whether the idea makes sense. It is something you could do a couple of times and play around with different combinations to come to some really solid ideas"*. Another group member stated *"We came up with a really good idea and know who to contact, why and what we might offer them"*. Similarly, groups in Amsterdam, Riga, Aalto and Lappeenranta stated that they would take ideas generated from the tool to colleagues to discuss further. One group in Riga operating within a specialised market, with few competitors, identified that their challenge was mainly legislative. This produced the idea that working with their competitors could reduce research and development costs, since all were required to meet the new material toxicity requirements. The Amsterdam groups, took a different approach: since both teams were from the same company they decided to use the tool to develop a short-term plan and a longer-term vision and strategy. Outputs included the planning of small-scale experiments to test ideas and a longer-term partnership strategy with key actors.

The other outcome is the realisation that groups needed to pivot or adapt their idea. One group within the Hamburg workshop stated *"the more we go through this tool the more we realise our original idea is [sic: not very good!]"*. The group pivoted their idea from sourcing and supplying reused and bio-based textiles to build a platform-based market place where multiple organisations could sell bulk items for secondary material processing or processed materials ready for reuse to bring scale and promote textile reuse across industries.

4.2.3. Insights on outputs from the circular pitch and action template

Table 2 presents an example output from the workshop produced by LUT team who focused on the Lappeenranta built environment challenge. This provides insights into the actions planned via the workshop.

4.3. Updated tool

The main tool design and facilitation improvement points, their underlying rationale, and evidence are provided in Table 3 and integrated into the tool, shown in Fig. 8.

5. Discussion

This study has developed and tested an ideation tool to identify partners and perceived value to collaboratively design circular propositions. Contributions, limitations and conclusions are discussed below.

5.1. Mapping and visualising to craft circular propositions

Tool demonstrations substantiates the literature findings that propose visualisation tools offer a good way to think and work collaboratively within the more abstract and creative ideation phase (Mansoori and Lackéus, 2020; Peters et al., 2020; Pieroni et al., 2019). The hands on mapping and visualisation, via a canvas, are found to help groups to share their knowledge and interpretation of a circular challenge (Elsbach and Stigliani, 2018; Micheli et al., 2019). Further, York et al. (2016) and Keskin (2015; 2020), propose sustainable entrepreneurs can engage stakeholders differently, based upon their orientation, when crafting a proposition to balance between the sustainability focus, the desirability for customers and feasibility to engage partners or the viability of developing the idea; our canvas supports this required openness, adaptability and perspective to finding synergies. This process supports users to develop scenarios based upon different challenges, customers, and partners. By providing discussion topics the Circular Collaboration Canvas (Fig. 8) acts as physical artefact that helps users collect, share, explore and order ideas (Elsbach and Stigliani, 2018). Further, this supports findings from Badke-Schaub et al. (2007), into mental models within teams, who propose distinctions across task, process, team and competences, show groups in co-design processes go through divergence and convergence sharing mental models to ascertain knowledge that is present and to create a common understanding of both the problem and solution space.

The tool, once filled out, provides an overview that helps users uncover and identify assumptions within their thinking, potential challenges, resources, customers and partners needed to better understand the systemic nature of their circular proposition (Chasanidou et al., 2015). This process challenges users to think deeper and more systemically upon their circular proposition. Use

Table 2
Lappeenranta city project: maximise use of existing building stock.

Circular Idea Pitch	Idea	24/7 Public spaces - pilot focus Kindergartens
	Can do	Develop an app that enables reservations to access underutilised public spaces and buildings to fit users' needs
	Improve Circularity	Maximise capacity of cities buildings. Narrows resource use, promotes sufficiency and reduces city/users need for new buildings
	This can bring	Reduced costs to city and users for community spaces. Share energy costs to run buildings. Aid loneliness, stress and time pressures on families. Help avoid waste of building capital and improves quality of life and sense of community
Action Template	We need to find out	A) Which neighbourhoods are most suitable to survey B) If parents are interested in the idea and costs can be covered
	We can find out now by	A) Engaging municipality building managers to assess building availability: initial focus on kindergartens B) Engage potential users (e.g. school clubs, sports clubs) living in neighbourhoods to assess needs
	We can get support from	A) Kindergartens in the specific neighbourhoods B) Contact Community engagement department in Lappeenranta City offices
	We know we are on the right track if	A) Actors in a neighbourhood agree to develop a pilot B) Desirability metric: 10/100 respondents are interested to participate in a pilot. Viability metric: assess additional costs and users willingness to pay. Do user payments cover additional costs. Circularity metric: does pilot result in reduced need for furniture and equipment purchases. Assess if use life of existing products is affected.

Table 3
Main improvement points from demonstration and evaluation cycles.

	Improvement Point	Rationale	Evidence
		Tool Design	
1	Remove numbered order. Future assess if colours increase separation of sections	Users can dynamically use the canvas to increase ideation. Explore visual separation.	User discussion: appreciated initial order, but also later desired freer ideation approach
2	Adapt and order partner questions horizontally to identify potential partners and engagement strategy	Supports identification of partners and provides an easier ordering to answer questions	User discussion (Hamburg & Riga): how to improve partner section. Observations: showed improved partner identification
3	Action template add question: What do you want to achieve (Immediately, 3–6 Months, 1 Year, 1 Year +)	Question aids next step planning for users	User discussion (Aalto and LUT): how to improve output of the canvas
4	In future explore digital interface for the canvas	Support scaling the use of the approach via digitisation	User discussion and feedback forms (LUT)
5	Improve Trigger questions e.g. Add examples where users struggled & questions on circularity and recovery	Examples helped to fill in the tool. Focus on circularity and recovery avoided 'business-as-usual' ideas	Users required and desired increased CE focus questions and examples to answer the trigger question. Users aided when prompted to think more directly upon their own skills, interests and what they have
	Change "what resources do you have to solve your challenge?" to "what are you good at and what do you have to solve your challenge?	Reframed question focuses on users "who am I" and "What do I know" to increase engagement with effectuations principles	User discussions for how to improve the use of the partner section
	Remove "Are they crucial" and add "what are you willing to share with them?"	Increases focus on perceived value for partners and the type of collaboration available	
		Tool Facilitation	
6	Linked to design change 1: Present proposed order; but can be explored dynamically	Allows both structured and dynamic approaches	Observations: groups used the tool differently. Iterating between or splitting sections. Then aligning to ideate as group.
7	Encourage quick individual answers then group discussion to consolidate ideas	Individual ideation to increase number of ideas and 'Messy' ideation can be concretised using the tool	Observation and facilitation notes: Approach more effective for users to balance ideation/consolidation activities and advance more quickly
8	Encourage groups to select a scribe to capture outputs and moderator for discussions	Key discussion points can become lost if not written down: Linked to facilitation points 7	Observation and facilitation notes: Groups who appointed scribes and moderators recorded more discussion topics and translated more ideas to post-its
9	Highlight identified customers can also be partners	Depending on the project focus customers can be partners	Observation & facilitation notes: Some users struggled till prompted that customers be partners
10	Create a space within work area for assumptions, unknowns, or to do's	Supports advancing within tool & helps identify knowledge gaps, next steps planning or further work	User discussion & facilitation notes: when used in later workshops aided users
11	Ideal set-up: project canvas. If unavailable print canvas as large as possible	Allows increased space for ideas & gets people up and out of seats	Observation: when projected users more active Feedback forms and discussion: Requested by users in workshops without multiple projectors
12	Prompt: idea development and planning is done via circular pitch and the action templates	Allows users to focus on mapping & visualisation in canvas, then generate multiple ideas from content	Facilitation notes: Informing users helped separate mapping & idea generation activities. Templates supported creation of multiple ideas
13	Prompt: Assign numbers to identified partner & work sequentially numbering each	Helps users to later track partner development & identify answers to specific partners when moving to idea generation	Facilitation notes: prompt helped users

of the 'circular pitch' and 'action template' aids users to think about different ways to test the desirability, feasibility, and viability of their ideas. These identify future actions, tests and early insights into potential metrics required to explore and add detail to the circular proposition. This integrates different approaches to advance the circular proposition and plan tangible actions. This supports with empirical evidence Mansoori and Lackéus (2020) and highlights wider integration could be valuable for tool development to overcome the theory-practice gap, notably proposed by Bocken et al. (2019) within their tool design development checklist.

5.2. Use of effectual based trigger questions

Effectual-based trigger questions within the canvas directed user discussions that supported users to think deeper upon their circular proposition. This helped them share their knowledge and work together to create a shared brain and narrative for how the circular proposition could work. The integration within an analogue collaborative ideation tool builds on Peters et al. (2020) and aligns with process-oriented criteria and contextual sensitivity for tools to allow contextual aspects to be explored (Bocken et al., 2019a,b; Breuer et al., 2018). Furthermore, trigger questions stimulated users to (re)frame circularity challenges, use empathic thinking to bring in needs and perceived value for stakeholders, and to explore alternatives (Beverland et al., 2016; Micheli et al., 2019). This aids the crafting and design of circular propositions.

Trigger questions presented in the tool focus users on the desirability of their circular proposition to customers or users (e.g. 'What does your product or service do to help?'), versus the feasibility of value creation and delivery (e.g. 'what are you good at and what do you have to solve your challenge') and the viability of value capture ('what is in it for them?'). This stimulated a more network-oriented and collaborative way of thinking needed to advance the circular proposition and triggered critical thinking around the activities (by whom) that would be needed. Moreover, considering partners by 'what are you willing to share?' and 'how will you assess their commitment?' stimulated users to think of their engagement strategy and produced discussions on perceived value for potential partners, building on the call by Fernandes et al. (2020). Such trigger questions were found to be valuable to provide a quick and low-cost practice to prototype and test ideas on paper. Asking the right questions to create insights can highlight assumptions or hypothesis that then prompt potential experimentation routes to test ideas. Aligning with work by Bland & Osterwalder on testing value propositions through experimentation (2019).

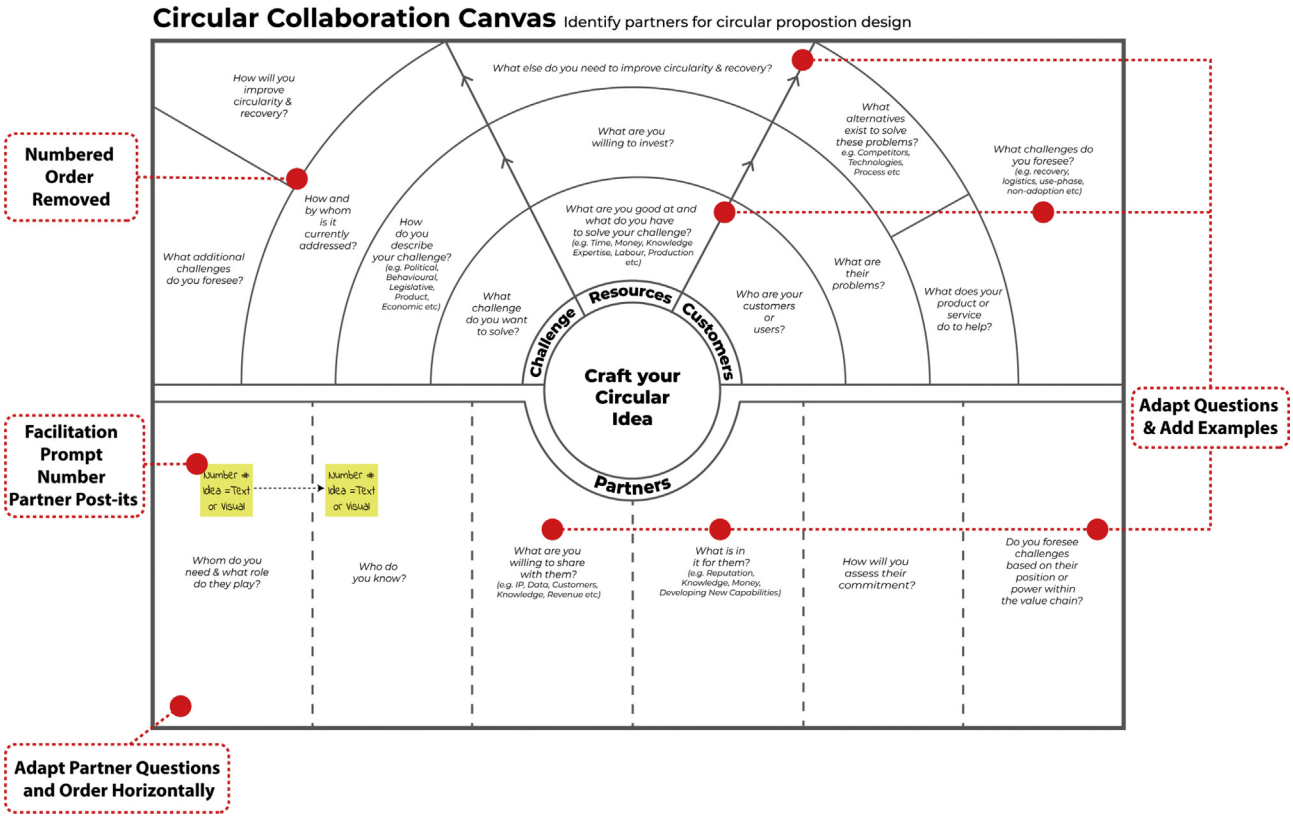

Fig. 8. Updated Circular Collaboration Canvas to identify partners for circular proposition design.

5.3. Practical use of the tool

The mapping and visualisation approach supported users within the early stages of a COI process to create an initiproject. This develops the proposition by Brown et al. (2020), who identified steps within the COI proal shared vision for a circular cess that could be supported by specific tool development. This study showed that this tool has value for both practitioners (to deepen and explore a circular proposition) and educators (to teach the required elements of COI development). Two main outcomes from using the tool are: 1) to improve the initial circular proposition by adding detail (resources, customers, and partners etc) and, 2) to pivot or adapt the circular proposition based on insights from mapping and visualising processes that indicated it was not feasible, viable, or desirable when bringing in the partner focus. Differences between the maturity and scope of projects were found: when the initial idea is clearer this improves the effectiveness of the tool. The tool is most useful when it is actively facilitated by an expert who is familiar with the background circular concepts to direct and challenge users to maintain a circular and recovery focus within discussions to avoid 'business-as-usual' ideas. Tyl et al. (2015), find a similar necessity for facilitation to improve the effectiveness of sustainability tools and this advances upon the notion identified in Brown et al. (2020) that a knowledgeable expert can act as a 'circular conscience'. Finally, the increasing user scores (Figs. 6 and 7) indicates rigorous and iterative user testing supports improvements to the design, use of and guidance for how to facilitate the tool, which supports insights from Bocken et al. (2019a,b) and tool development checklist they propose.

5.4. Limitations and future research

This study represents an explorative investigation into tool development for collaborative COI. As such, it holds limitations. Firstly, although the challenges used within the tool were active and brought forth by users, in the workshop the focus was on one challenge per group. We asked users to self-select into a challenge that was of interest to them, but these are not always their direct challenge or knowledge area. This is a slightly artificial setting: ideally the challenge would be shared by all users within a group. Also, since the users formed teams, this meant some time was spent on learning who is present within the team. In an ideal setup, users would share ownership of the challenge and have had some engagement time prior as a team. Secondly, limitations derive from data collection through an action-research approach, which included researchers facilitating workshops. It is acknowledged how this could lead to bias or prompt responses. We aimed to limit this by including multiple researchers collecting data from multiple sources.

Future research should repeat design-demonstration-evaluation cycles to improve the usefulness and ease-of-use of the tool. Advice is to explore, with a preference upon individual companies or existing professional groups who share a common challenge. Additionally, further testing variations in the scope of projects, users, or organisations to understand appropriate contextual sensitivity is needed. Moreover, two interesting avenues for further research are held within conducting longitudinal action-research. One is to follow users to assess the effectiveness of partner ideation and crafting of the circular proposition by

monitoring advancement or implementation. This opens the second possibility to repeat the exercise, using an adapted version of the tool, within the collaborative setting of identified partners. This approach is particularly critical within CE as operationalisation relies upon systems of actors and moving beyond firm-centric approaches towards business models (Bocken et al., 2019; Konietzko, Bocken and Hultink, 2020b). Adapting the current tool to develop one for a collaborative modelling process holds promise to facilitate and advance collaborative circular proposition and business model design. Finally, more generally, future tools in the field of CE could benefit from a similar iterative design-demonstration-evaluation approach and taking an interdisciplinary perspective on tool development.

6. Conclusion

This study contributes through the design and testing of the circular collaboration canvas. The canvas supports users within the early stages of a COI process to quickly ideate to identify partners and perceived values and then map and visualise these to design circular propositions. We contribute to circular oriented innovation literature by demonstrating that: (1) integrating entrepreneurial and innovation approaches to develop tools and guided facilitation processes can increase the usefulness, ideation potential and practical guidance provided to support circular proposition design, and (2) combining visualisation approaches with asking specific questions relevant to topics can support users to trigger effectual-based ideation. This prompts users to identify available means, potential partners, and perceived value to bring in a partner and systemic perspective when designing a circular proposition within a given and uncertain context. This process quickly identifies assumptions, knowledge gaps, required experimentation and actions that are needed to test and improve the desirability, feasibility and viability of the circular propositions. Mapping partners and perceived value prompts users to deepen, improve or pivot their circular proposition. This balances trade-offs, creates synergies or overcomes challenges held within the design of circular propositions. We recommend further demonstration of the tool is required to understand and assess how elements such as the maturity and scope of the circular proposition addressed, skill-levels and mix of participants, as well as levels of facilitation, can affect the perceived usefulness, ease-of-use, and development of tangible outputs and the design of circular propositions. Furthermore, we recommend researchers to increasingly pursue action-based research and testing of tools within practice based contexts to bridge the theory-practice gap.

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CRediT authorship contribution statement

Phil Brown: Conceptualization, Methodology, Investigation, Data curation, Visualization, Writing – original draft. **Brian Baldassarre:** Conceptualization, Investigation. **Jan Konietzko:** Conceptualization, Investigation. **Nancy Bocken:** Writing – review & editing, Supervision. **Ruud Balkenende:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2021.126354.

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